POWER

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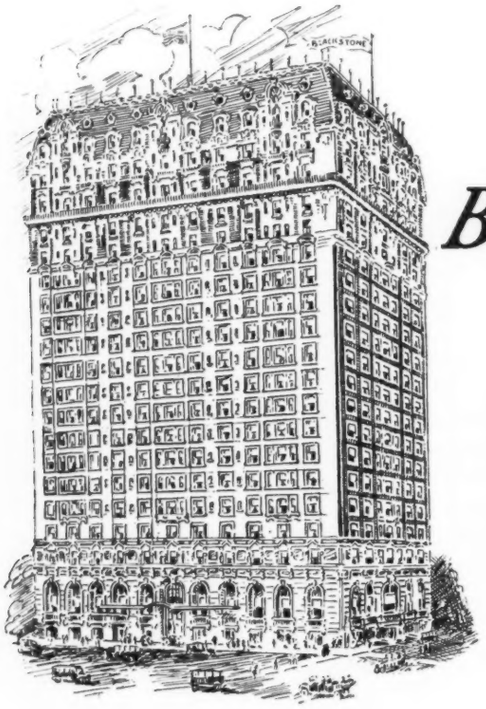
He is faced by the prospect of a long wait, unless he decides to disregard the flood and drive through



Saving Coal in the Blackstone Power Plant

By W. A. Eberman*

Remodeling of the boiler furnaces together with the cooperation of the operating force and the intelligent use of instruments resulted in a saving in fuel amounting to 12 per cent. One of the greatest features incorporated was the improved furnace conditions brought about by the installation of a type of stoker that was guaranteed to operate with an efficiency of 70 per cent under normal operating conditions. The efficiency of the men was mainly the result of explaining things to them and what was expected to be accomplished.

IN THESE columns the power plant of the Blackstone Hotel has had previous mention. The present article has to do with a 12.3 per cent. saving in fuel. Last year the coal consumption was 1543 tons less than the average for a period of six years. In other words, the average consumption of 12,561 tons of coal was reduced to 11,018 tons. The saving was due to a change in boiler-room equipment made desirable by the rising cost of fuel, to better coöperation from the operating force and intelligently directed support from the management of the hotel. One of the greatest factors was improved furnace conditions. The stokers originally installed had never been entirely satisfactory, owing principally to deviations from standard design to conform with space limitations. War-time prices for coal emphasized their deficiencies and led the management to substitute stokers better suited to the requirements. The results of tests made on duplicate boilers, show that the change was justified.

TEST RESULTS FROM OLD AND NEW FURNACES

	Old Furnace	New Furnace
Time, hours, minutes	7	8-14
Total water evaporated, lb.	86,784	101,232
Temperature feed water, deg. F.	210	210.9
Coal burned, lb.	11,902	11,763
Apparent evaporation, coal as fired, lb.	7.29	8.6
Equivalent evaporation, coal as fired, lb.	7.65	9.03
B.t.u. coal	11,900	12,179
Efficiency, per cent	62	71.5

Corrections are not made for quality of steam in either test. The coal cost of 1000 lb. of steam at the prevailing price of $3.15 per ton was 21.6c. with the old grates and 18.4c. with the new stoker. The ratio of the efficiencies obtained is within 1 per cent. of the ratio of the annual coal consumption figures given at the beginning of the article.

The duty of the plant is to furnish lighting, power, heating, ventilation, elevator service, air and icebox refrigeration, ice for the kitchen and restaurants, water and laundry service for a hotel of 425 rooms. The adjoining theater, and the help's dormitory are heated and lighted from the hotel plant. Exhaust steam is sufficient for heating purposes when the temperature is above 20 deg. F., live steam being needed to supplement the exhaust when the temperature is lower. As this article is to deal primarily with the boiler room, the steam-using end of the plant may be passed over with the statement that it contains the necessary apparatus to supply the services previously mentioned, and is considered modern.

The steam load is greatest in winter, when it reaches a maximum of 1200 boiler horsepower and is practically the same day and night. The temperature determines the load after 20 deg. F. is reached. When air refrigeration is required to cool the restaurants, the summer load is about 850 hp. on two shifts and 300 to 350 hp. on the third shift. Between these seasons the load is around 750 hp. for two-thirds of the day, which in

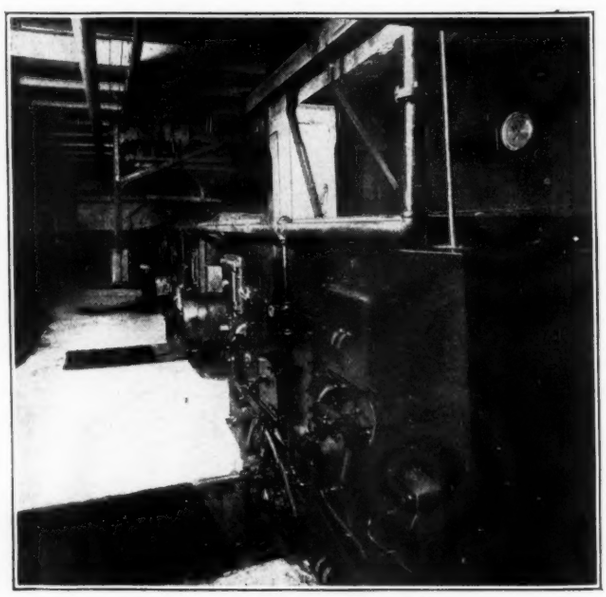


FIG. 1. BLACKSTONE HOTEL BOILER ROOM

*Chief engineer, Blackstone Hotel.

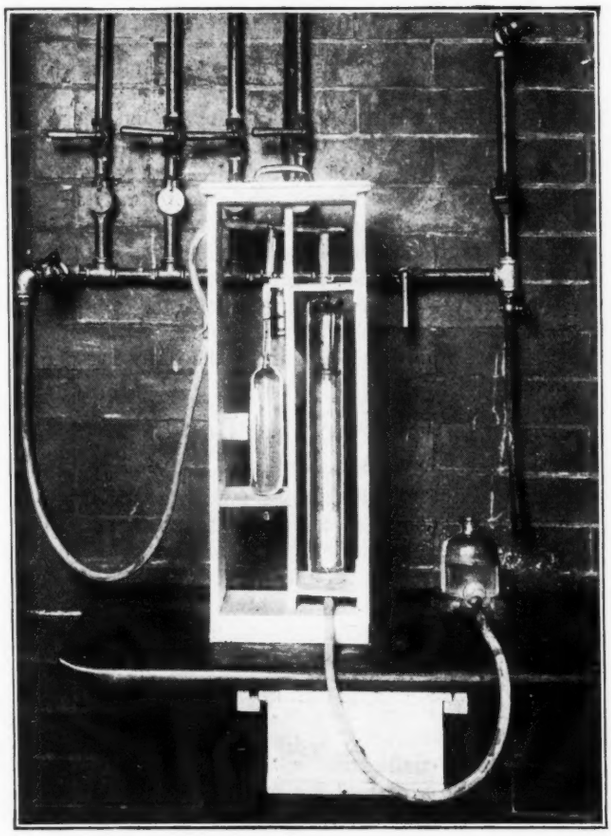


FIG. 2. CO_2 ELEMENT FOR USE OF FIREMEN

hotel work is always a full 24 hours. For the balance of the time the requirements are the same as the midnight-to-morning load in summer. The load varies from day to day as well, being affected by the volume of business.

The boiler plant is made up of four 250-hp. water-tube boilers equipped with side-feed stokers. The boilers are set singly with a scant two feet between them and are connected with a long breeching to a stack that rises 328 ft. above the grates, giving more draft than is needed.

Individual dampers, with the controlling rods brought to the front of the boilers where they are convenient to the fireman, control the air supply. Draft gages are mounted on the front of each furnace. Mechanical soot blowers have been installed recently, but have not been in use long enough to have had much influence on the figures previously given. Coal is taken from overhead bunkers by means of an electrically driven weigh hopper and delivered to the furnace without the necessity of shoveling. Coal weights are recorded on suitable forms by the fireman on each watch and checked against the venturi meter on the feed line. The boiler settings are good, and a rigid inspection with prompt repairs keeps air leakage to a minimum. Elastic coating on the brickwork and sealed clean-out doors help in this.

With conditions as outlined, the highest everyday efficiency with the old furnaces was about 60 to 61 per cent. Many attempts were made to improve these figures but without success. When the load was just right, which was a small part of the time, fair results were obtained. The trouble seemed to be lack of air control and flexibility. Light loads meant short fires and low economy. Heavy loads on the shortened grates meant thick fires and heavy drafts which pulled in air around the end of the grates and along the sides where the fuel burned away faster than at other points. There was not sufficient space between the settings to work the fires from the sides. The short grates called for No. 3 or No. 4 washed nut of good quality. Moderate loads could not be handled with screenings or other comparatively slow-burning coals. Another thing that lowered the over-all efficiency was the necessity of keeping a third boiler ready to work at all times, even when two boilers would handle the load.

The stokers were ordered with a guarantee of 70 per cent. efficiency under normal operating conditions. The first unit was started in September, 1916, and after a short run a test was made by the operating force that showed an efficiency of 71.5 per cent. at 50 per cent. overload. A second furnace was dismantled as the material for its replacement was shipped, but it was lost in the freight congestion that occurred at that time, and did not reach the plant until late in January, 1917. In October, 1916, the coal situation became serious, and from that time until spring it was necessary to take any kind of coal that could be obtained. The heating load came on and there was many an anxious moment with steam at a point dangerously near the shutting-down point. The old furnaces could do little with the fuel available, and the brunt of the work fell on the one new stoker that had been installed. These conditions prevailed until early in February, when the second stoker was ready and the troubles were over, as the two would carry the entire load, which at one time for a week of very cold weather held steadily around 1200 boiler-

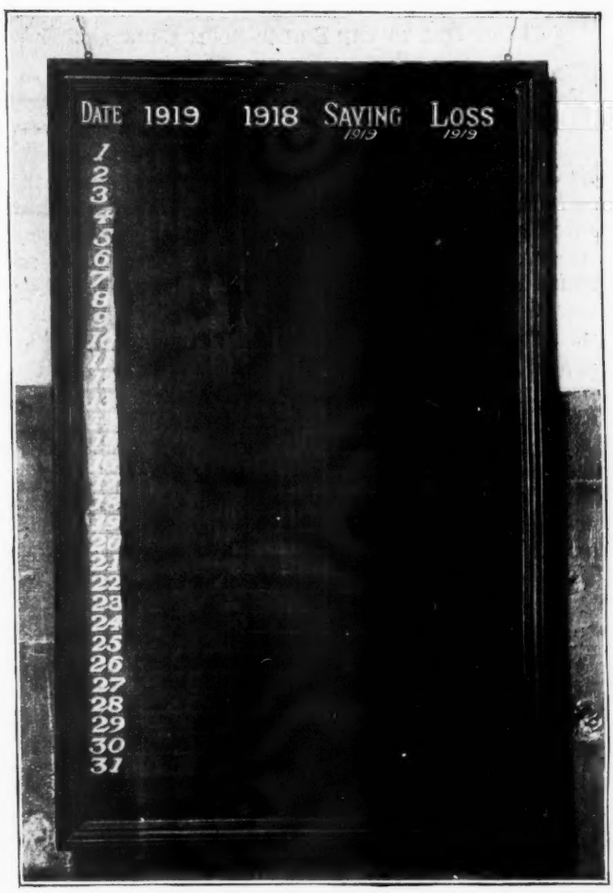


FIG. 3. COAL BULLETIN BOARD

horsepower. The last of the four new stokers was installed in October, 1917.

During last summer one boiler was made to carry the entire load for a period of a week to determine the limit of its capacity. The load during two shifts was 700 hp., and there was no special difficulty in keeping up the pressure. Complete data were not secured during this run, but it was noticed that the CO_2 was uniformly high—higher in fact than was desirable, 16.5 per cent. being easily obtained. The evaporation was somewhat lower on the two heavy shifts for the uptake temperatures were high. Better results were noticed during the light-load period when the load dropped to around 350 hp. The conclusion drawn was that the grate area was excessive, and three of the grates have been shortened. It is planned to cut them down still further, and run that way until winter. A large reserve capacity is at hand for emergency.

The new outfit has demonstrated its ability to carry heavy overloads, to burn grades of coal inferior to that used regularly—No. 4 washed nut—and to burn them efficiently. There was not much variation from the guaranteed efficiency of 70 per cent. even when burning screenings, as was necessary during periods of coal shortage last winter and at the request of the Fuel Administration last summer. Burning screenings was profitable when the price of coal was low and the difference in the price of washed coal and screenings was relatively greater, but with a difference of only 40c. and the price per ton $5.60, there was no inducement to continue with this fuel, for screenings are harder to handle, make more ash and foul the heating surfaces more than washed coal.

Credit Due to the Boiler-Room Crew and Watch Engineers

For the saving made, credit is due to the interest taken by the boiler-room crew and the watch engineers in making the new equipment live up to expectations. The chief engineer claims only the credit of procuring and holding a set of men who have coöperated with him so well. In his opinion the secret of getting intelligent men to strive for high efficiency is to keep them informed as to the aims of the management, letting them know the results they are getting and giving them credit for their efforts. A reward in money cannot always be given, but appreciation can be shown and the men impressed with the fact that they are a real part of the business. The firemen like to know the reasons for things that involve a departure from their accustomed methods, and they have a right to know. It has been the policy in this plant to explain things to the men—what is expected to be accomplished, what it means to the hotel in general and to the reputation of the department in particular. A complete set of records is kept, not locked in a vault, but placed in a wall case open to the inspection of any employee at any time, and they watch them, too. An elaborate bulletin board ruled in columns is placed in the boiler room. The first column shows the coal burned the day before, the second the consumption during the corresponding day of the previous year, the third column the gain over the previous year and the fourth the loss, if any. Recently, there has been no use for the last column.

For years an Orsat has been used on special occasions, but when the new installation was started the outfit was rebuilt to make it easier to operate and lines of permanent piping were carried from each boiler to a point in a pleasant place where the work could be done in a comfortable manner. A sample of gas is drawn quickly through pipes of ample size by the house vacuum system and then through the burette by the same means. The system of valves is such that it is only a moment's work to switch from one boiler to another, bringing over a fresh sample while the one in the machine is being analyzed. Recently, a duplicate of the outfit just mentioned has been permanently installed at the entrance of the boiler room, for the exclusive use of the firemen, who have readily learned to use it and to make use of the readings they get. It shows its value in the evaporation column of the daily log and on the bulletin board.

Double-Service Boiler

A new method of separating scale-forming solids, mud, oil or other foreign matter (with the exception of common salt), such as is commonly found in stationary power steam boilers is illustrated herewith as applied to a horizontal return-tubular boiler. The apparatus consists of a live-steam feed-water purifier located in a horizontal fire-tube boiler, which may be of the locomotive, Scotch or horizontal return-tubular type.

In the construction of the purifier first a plate *A* is attached to the front head with an angle iron and the flanged sides are attached to the shell with a few rivets, the joints being made tight with metal cement. Above the plate *A* is a trough *E P* supported on legs attached to the plate *A* in such manner that the trough can readily slide out. This trough is open at the end nearest the boiler head and closed at the opposite end. It is in two parts, one being a water-seal box *P* in which the feed water discharges. In the water-seal box the water escapes into *E* by overflowing through the steam, thus quickly increasing its temperature to that of the steam. From the end of *E* the water reverses and flows forward to the escape slot, which discharges into the boiler in a thin film. In front of the escape slot a shield *J* is provided that causes the water to underflow the shield in escaping through the slot into the boiler proper. This operation is simple. Assume the water level to be in line with the slot, then water added by the feed raises the level and water escapes from the slot in an equivalent amount, and this process proceeds constantly.

At the head end containing the slot a door is provided and is attached with bolts having their heads spot-welded on and provided with brass capnuts so arranged that the door is easily removable, thus enabling the trough *E P* to be slid forward. By removing the internal feed pipe, the trough may be readily withdrawn for cleaning, inspection, etc.

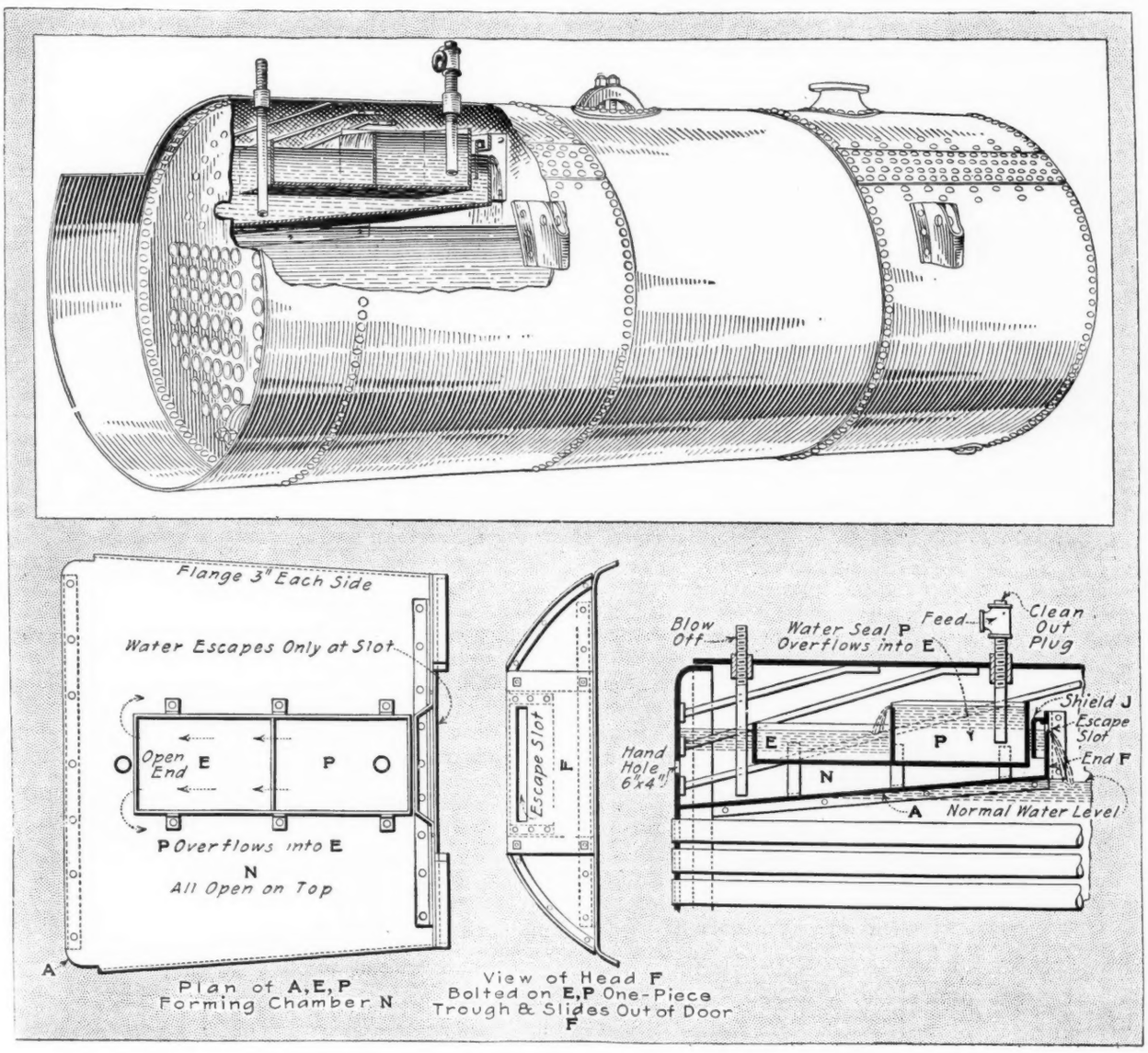
Since no portion of the fire strikes the parts of the purifier, it follows the deposits therein being in water do not bake on as they would in the boiler, but remain as mud easily blown out through the blowoff pipe. In addition, a handhole provided in the front head affords an opening for cleaning, inspection, etc.

The value of the underflow method of escape is based on the way the calcium solids are liberated and become insoluble or in suspension. The carbonates and sulphates are in solution owing to carbonic and sulphuric acids respectively. When heated sufficiently, these gases separate from the atoms of calcium and rise to the surface of the water and escape as gases. The atoms are carried to the surface in this progress and remain there

until finally they accrete together and by gravity fall to the bottom, since the shield *J* prevents all flocculent floating matter escaping from the purifier. Carbonates are set free at lower temperatures than sulphates, the latter being liberated at or under 280 deg. F., which is the temperature of steam at 50 lb. absolute, or 35 lb. gage pressure. The purifier receives and absorbs heat from the water on its bottom sheet, also on the surface of the water and at the overflow from the water-seal box *P* into *E*. The result is that the feed water, when it tained in the boiler. The purifier can be blown down readily at any time while the boiler is under pressure.

Consider the scale problem. Take a 200-hp. boiler running 24 hours per day, 30 days, using water containing only 15 grains per gallon. At the end of the run, there would be over 1100 lb. of lime deposits. Boiler-insurance experts say that over 50 per cent. of the boiler accidents are chargeable to foreign matter, scale, etc.

It is contended that not only does the "double-service



DOUBLE-SERVICE BOILER AND DETAILS OF FEED-WATER PURIFIER

escapes through the slot, is about as hot as the water in the boiler proper.

The diagonal braces are not interfered with in any way, and the steam room remains ample, in fact is greatly in excess of that of water-tube boilers. Foaming cannot occur since the cause, flocculent matter, is removed. The purifier is an integral part of the boiler and has no upkeep charges and requires no repairs at any time in the life of the boiler.

Carbonates, sulphates, magnesia, mud and oil are retained in the purifier just as otherwise they would be re-

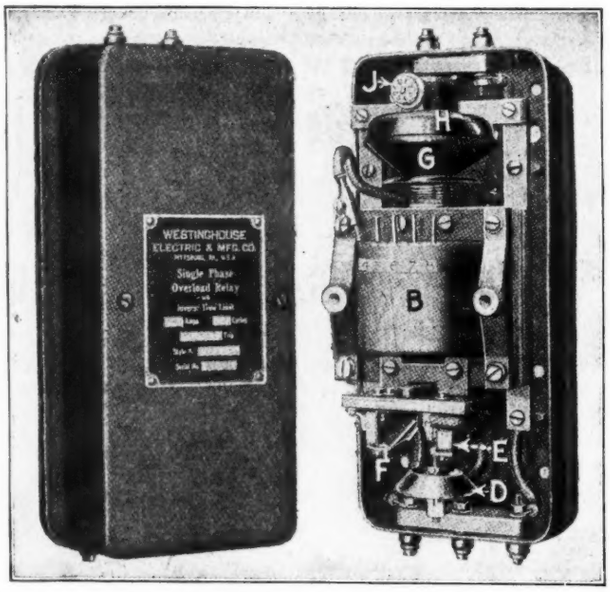
boiler" purify the feed water at small expense, but also by preheating the feed water the boiler is not subjected to the expansion and contraction stresses of the common methods of feeding. The apparatus complies strictly with paragraph 315 of the A. S. M. E. Boiler Code as respects an auxiliary feed-water heating and circulating device, also with paragraph 316 as respects the feed not discharging near riveted joints in the shell or furnace sheets.

The designer and patentee of the Double Service Boiler is Thomas T. Parker, of Brooklyn, N. Y.

Alternating-Current Plunger-Type Relays

By VICTOR H. TODD

THE great need of continuous service under all conditions has gradually caused the crude types of relays of a few years ago, which sometimes gave protection under special conditions but often failed at the critical moment, to be changed to the highly developed present-day types, which are built with the accuracy of a watt-hour meter and can be depended upon in practically all conceivable cases of electrical distress. In alternating-current systems, the need of continuity of service is so great that the lines must be kept alive until there is no chance of the disturbance clearing itself. In some states the public utility boards require an explanation of each and every interruption that occurs in an operating company's service as well as a report of the steps taken to prevent its recurrence.



FIGS. 1 AND 2. INVERSE TIME-LIMIT RELAY COMPLETE AND WITH COVER REMOVED

Many power-plants and factory managements have required in the past duplicate supply lines, so that their power supply would not be interrupted in case of trouble on other parts of the system. Others have maintained stand-by plants ready to assume the load in case of electrical trouble.

As a typical example of how protective relays have eliminated this necessity, one operating company had as many as 25 interruptions a year, but after making an intelligent survey of the system, a few changes were made in the sectionalizing apparatus and accurate relays installed which reduced the interruptions to about one annually, although the system suffered not less than one hundred short-circuits per year from various causes.

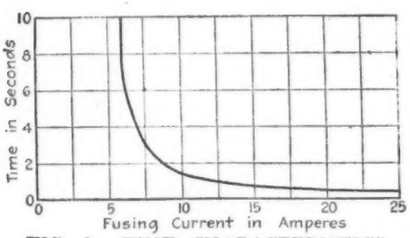


FIG. 3. TIME CHARACTERISTICS OF A FUSE

The relays instantly sectionalize and isolate a defective line or piece of apparatus without disturbing the rest of the system. This allows spare lines to be used continually, and the great saving and economy of copper will often finance the installation of relays.

Before describing the various types, or deciding on a certain system of protection, it is well to consider the basic principles of protection. What is an interruption? How long may an overload exist? How long can a short-circuit exist before it must be cleared?

An interruption occurs when the voltage ceases long enough to cause an induction motor to reduce its speed so far that it will draw an excessive current should the potential be applied suddenly, or when synchronous apparatus falls out of step. This time is usually about two seconds, so it is evident that a "dead" short-circuit must be cleared in two seconds or less. Moderate overloads of a few hundred per cent. need not be cleared so quickly, as modern generators are built with enough overload capacity to withstand considerable overload without damage. Consequently, in a simple circuit requiring protection, the time between the instant of overload and the opening of the breaker should be inversely proportional to the excess of current. An ordinary fuse gives this desired inverse-time limit to some extent, as will be seen by referring to Fig. 3. It will be noted that a current of 5 amperes will not blow the fuse, 6 amperes will blow it in 6 sec., 7.5 amperes in 3 sec., 10 amperes in 1.25 sec., 20 amperes in 0.5 sec., etc.; but above this value the time becomes practically instantaneous. It is obvious that instantaneous operation on a short-circuit is not always desirable, as the short may burn out or clear itself in less time than it takes to cause a loaded motor to slow down appreciably.

[Note: The terms circuit-breaker and oil switch are used synonymously in this article.]

The first circuit-protecting relays were made with an inverse time limit. In other words, instead of the load current acting directly on the oil switch and opening it instantly in case of trouble, the excess current operated a relay, which, after a predetermined time, opened the circuit-breaker.

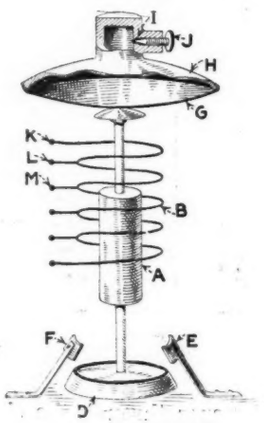


FIG. 4. SCHEMATIC DIAGRAM OF RELAY FIGS. 1 AND 2

Fig. 1 shows a typical overload relay which obtains the time limit by means of an air bellows. Fig. 2 shows the same relay with the cover removed, and Fig. 4 is a schematic diagram of the same. The iron plunger *A*, working under the influence of the solenoid *B*, carries at its lower end an insulated disk *D* having on its circumference a band of nonoxidizing metal. When the solenoid coil *B* is energized by a current of a certain strength, the core *A* is pulled upward, thus forcing the

disk *D* against the contacts *E* and *F*, completing a circuit to a shunt-trip coil on a circuit-breaker. On the upper end of the plunger shaft is a leather bellows *G* fastened to the permanent support *H*, so that as the plunger rises, it compresses the air in the bellows and resists its upward motion. This air is permitted to

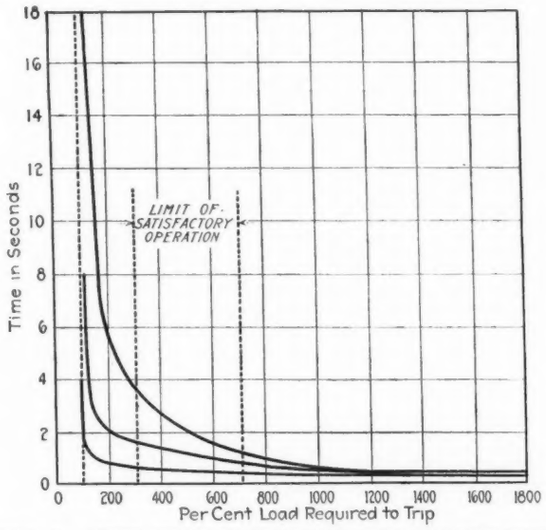


FIG. 5. TIME CHARACTERISTICS OF BELLOWS-TYPE OVERLOAD RELAY

escape gradually through a little opening at *I* in the casting, and this gradual escape of air allows the plunger to rise in a certain time to complete contact at *E* and *F*. These parts are also indicated in Fig. 2.

It is evident that the greater the current in the solenoid *B* the greater will be the upward pull, consequently the greater the compression in the bellows, the quicker the escape of air and the shorter the time. That is, the greater the overload the quicker the circuit will be opened.

This inverse proportion is not a fixed factor, however, since by varying the size of the escape aperture at *I* by means of the valve *J*, the time may be varied from almost nothing to 15 or 20 sec., and still have the inverse time limit.

The taps *K*, *L*, *M*, etc., are provided to change the number of turns in circuit and consequently the amount of current required to operate the relay. For instance, this particular relay has taps for 4, 5, 6, 7 and 8 amperes. This means that if the 4-ampere tap is in circuit, the plunger will start to rise when the current reaches 4 amperes; with the 5-ampere tap, the plunger will rise when the current reaches 5 amperes, etc.

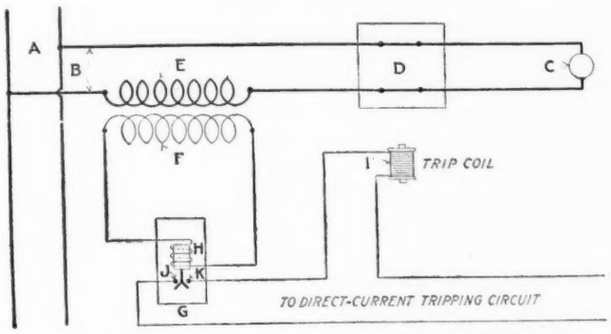


FIG. 6. DIAGRAM OF RELAY CONNECTIONS ON SINGLE-PHASE CIRCUIT

As a practical example, assume that the relay is used with a 100 to 5 current transformer. This means that when the full-load current of 100 amperes is reached there will be 5 amperes passing through the relay coil. But if connections are made with the 4-ampere tap, the relay will operate on 4 amperes, which, in the ratio of 5 to 100, means that it requires only 80 amperes to operate the relay with this setting. Should the 8-ampere tap be connected in, the relay will not operate until there is a load of 160 amperes on the primary of the transformer. This might take 18 sec. to trip the oil switch. But with the same setting, a load of 300 amperes might take only 4 sec.; 600 amperes 1.5 sec.; 1000 amperes 1 sec.; and so on in time inversely proportional to the current.

This inverse time is not a straight-line inverse time,

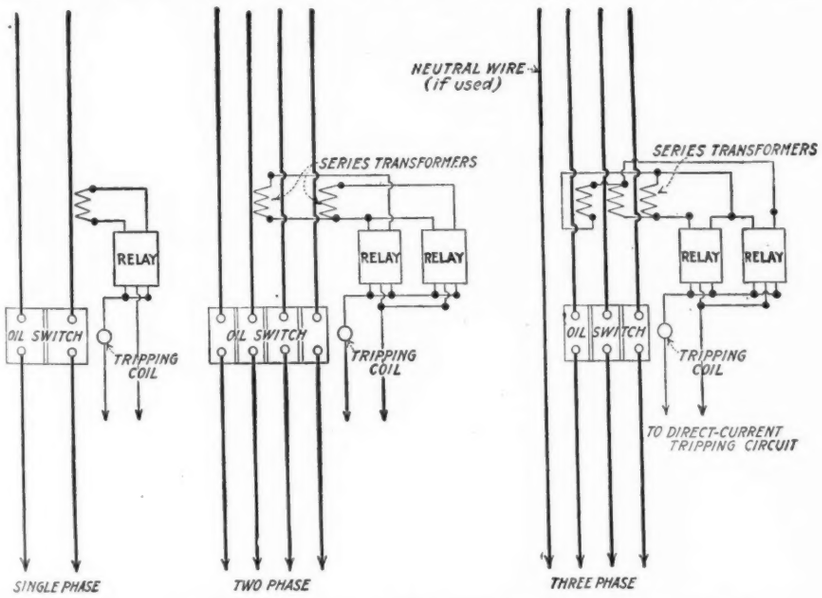


FIG. 7. DIAGRAMS OF RELAY AND TRANSFORMER CONNECTIONS FOR A DIRECT-CURRENT TRIPPING CIRCUIT

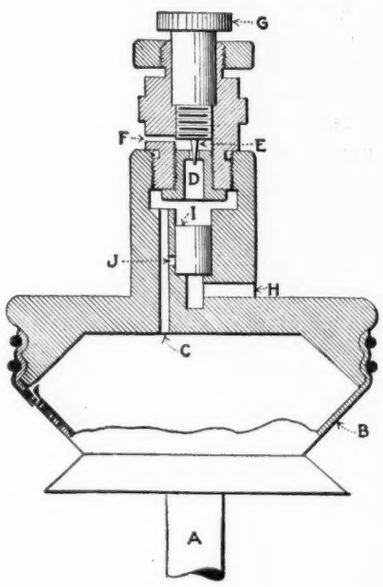


FIG. 8. RESETTING DEVICE ON RELAY SHOWN IN FIG. 9

but follows a curve such as that shown in Fig. 5. It will be noticed that this curve is very similar to the time curve of a fuse, but has the distinct advantage that it may be varied at will, and the relay is accurate and can be depended upon, and is automatically reset each time it operates.

One relay is necessary for the protection of a single-phase circuit and two for a two-phase or a three-phase circuit. Fig. 6 shows the diagram of connections of a single-phase circuit. *A* is the busbar supplying the feeder *B*, which in turn supplies the load *C*, and the circuit-breaker *D* opens and closes the circuit. *E* is the primary winding of a series transformer and *F* the secondary, which is connected to the relay and energizes the solenoid *H*. The direct-current circuit is connected to the shunt-trip coil of breaker *D*, with a break in the circuit at contacts *J* and *K*. This diagram shows the normal operating position.

If an overload occurs at *C* and excess current in the transformer *EF* results, the relay plunger rises, short-circuits the contacts *JK* and completes the trip circuit; an instant later the oil switch will open, disconnecting the line. Fig. 7 gives diagrams of relay and transformer connections for protecting single-phase, two-phase and three-phase circuits.

Another bellows type of relay is shown in Fig. 9. This is a single-phase unit, but they are also made with two and three relays mounted on one casting to protect two- or three-phase circuits. However, they will require two or three separate series transformers just as the relays previously described will. It will be noted in this type that the contacts are at the top, and protected by a removable cover, permitting ready inspection.

In this relay the various load settings are not obtained by taps, but by varying the position of the iron plunger in the solenoid by an adjustment at *A*. Lowering the plunger requires more current to raise it, and raising the position requires less current.

The time setting is varied by an air valve in the top of the bellows casting, as shown in Fig. 8. When an overload occurs, the solenoid raises the plunger, thereby raising the stem *A*. This compresses air in the leather bellows *B*, forcing it up the channel *C*, through the valve *D*, past *E* and out at *F*. The time is adjusted by varying the position of the pin *E* by turning *G*. A good feature is the quick-resetting device shown at *H* and *I*. *I* is a cylinder which, on upward travel of the stem *A*, is forced against opening *H* and effectually closes opening *J*. When the relay attempts to reset, the air is rarefied in the bellows and cylinder *I* is lifted, allowing air to enter *H* and *J*, thereby insuring a quick resetting of the plunger.

One drawback to the leather-bellows type relay is that the leather, unless attended to carefully, will harden in time and crack, thus defeating the purpose of an accurate time. To overcome this, relays of the type shown in Figs. 10 and 11 have been developed. These have the contacts at the top, as in the type Fig. 9, but the bellows is omitted and an oil dashpot is placed at the bottom of the stem as shown in Fig. 11.

Instead of forcing air through a needle valve, oil is forced by a piston on its upward travel through the valve *E* and out of hole F, Fig. 10. The piston *C* has a number of holes in the bottom, which are normally covered by the disk *D*. Upon upward travel the disk closes the holes practically oil-tight, but on downward travel it rises and allows a quick resetting of the plunger.

FIG. 9. INVERSE TIME-LIMIT OVERLOAD RELAY

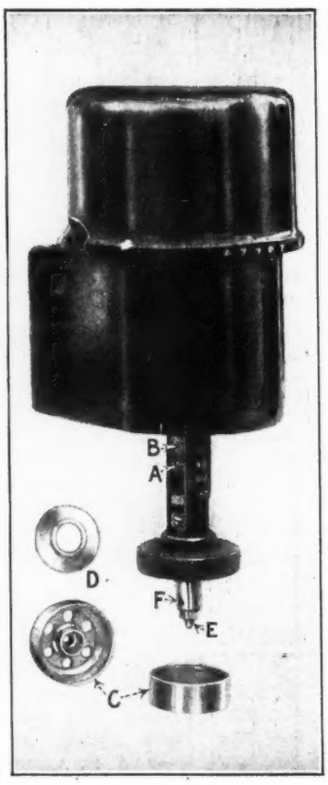


FIG. 10. SHOWS DASHPOT DETAILS OF RELAY, FIG. 11

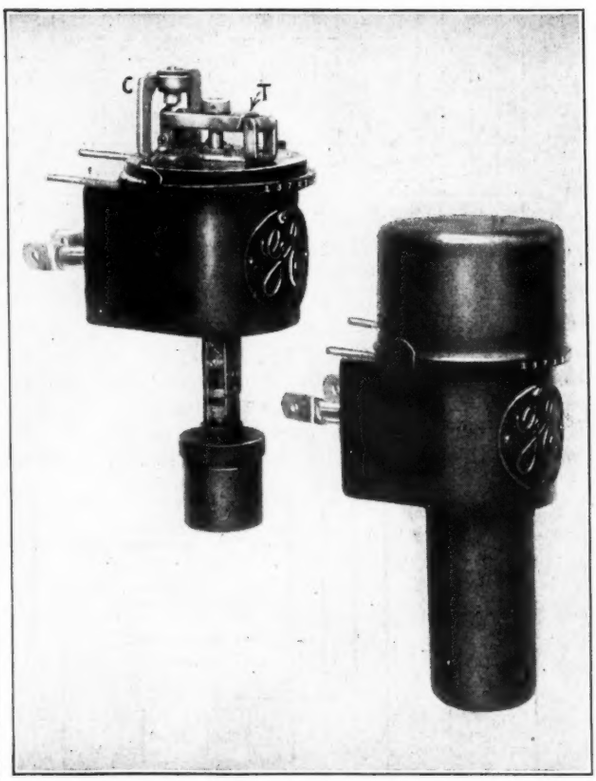


FIG. 11. DASHPOT-TYPE INVERSE TIME-LIMIT RELAY WITH COVERS REMOVED AND IN PLACE

These relays cannot be used where they are subjected to extreme changes in temperature, and no other oil except that supplied by the manufacturers should be used in the dashpot. Their time may be varied from almost instantaneous at heavy loads, to over 5 min. at 150 per cent. load.

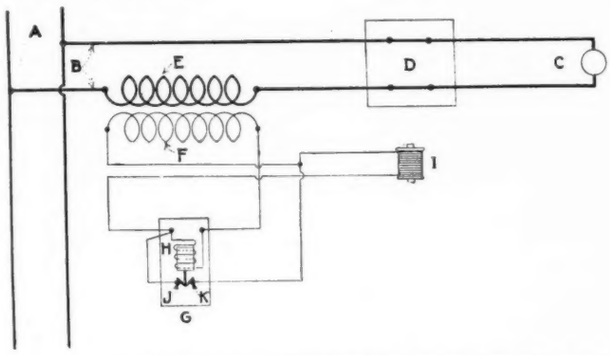


FIG. 12. DIAGRAM OF CONNECTIONS FOR SERIES-TYPE INVERSE TIME OVERLOAD RELAY

Sometimes, as in radial systems an inverse time is not so desirable as a definite time. To obtain this, the relays heretofore shown are slightly modified so that instead of the plunger being rigidly attached to the bellows and contact shaft, the raising of the plunger merely compresses a spring, which in turn raises the shaft. This is shown in Fig. 13. The plunger *A* is free to slide up on the shaft *N*. When it rises, it compresses the spring *O*, which presses against a stop rigidly attached to the shaft, at the bottom of the bellows, thereby rising in the shaft and contacts.

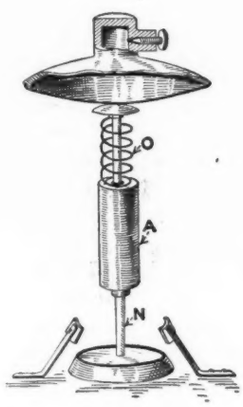


FIG. 13. DEFINITE TIME LIMIT OVERLOAD RELAY

It will be readily seen that no matter how much current is passed through the solenoid, once it rises, there can be no greater compression from the spring no matter what the load. Consequently, the contacts are closed in a definite time, depending upon the time setting after the raising of the plunger. Hence the name, "definite time-limit overload relay."

In the examples shown, it was assumed that there was always a separate direct-current circuit which the relay completed to trip the oil switch. Sometimes a source of direct current is not available, so the secondary current of the series transformer is used to trip the circuit-breaker. These relays are known as series-trip or circuit-opening types. The secondary of the transformer is connected to the trip coil on the breaker, but this coil is short-circuited normally by the relay contacts. When the relay operates, it connects the trip coil in circuit, thereby causing all the current to flow through it and open the oil switch. This is shown in Fig. 12, in which the feeder *B* is supplying the load *C* through the current transformer's primary *E* and protected by circuit-breaker *D*. The secondary of the transformer *F* is connected through the relay *H* and the trip coil *I* on the oil switch *D*. The trip coil is short-circuited by the contacts *J* and *K* on the relay. An overload at *C* causes excessive current to flow in the relay coil *H*, which raises its plunger and opens the contacts *J* and *K*, causing current to flow through the trip coil *I*, which opens the oil switch. Fig. 14 gives diagrams of relay and transformer connections for protecting single-phase, two-phase and three-phase circuits.

The series-trip relays have an advantage in that they do not require a separate circuit to trip the circuit-breaker. However, unless they are equipped with solidly closed contacts, they are liable to trip the breaker on a slight jar or knock.

One type of series-trip relay, Fig. 11, closes the contacts *C* by a toggle *T*, which is closed on the downward travel of the plunger, thereby insuring very positive connection. When the plunger rises, this opens the toggle, allowing a spring to open the contacts with a quick positive action. It is possible to combine the advantages of a definite-time and an inverse-time relay in a single unit, which is made on the same lines as a watt-hour meter and has watt-hour meter accuracy, but has not the torque necessary to operate a toggle. This type will be discussed in a future article.

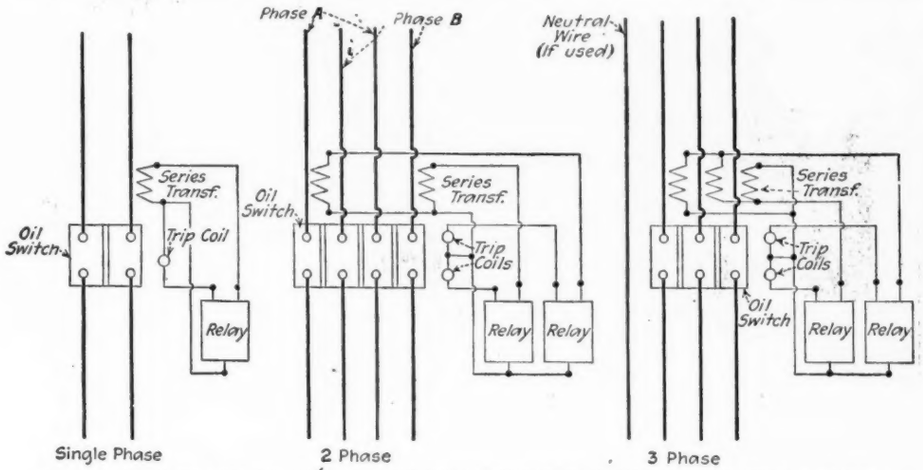
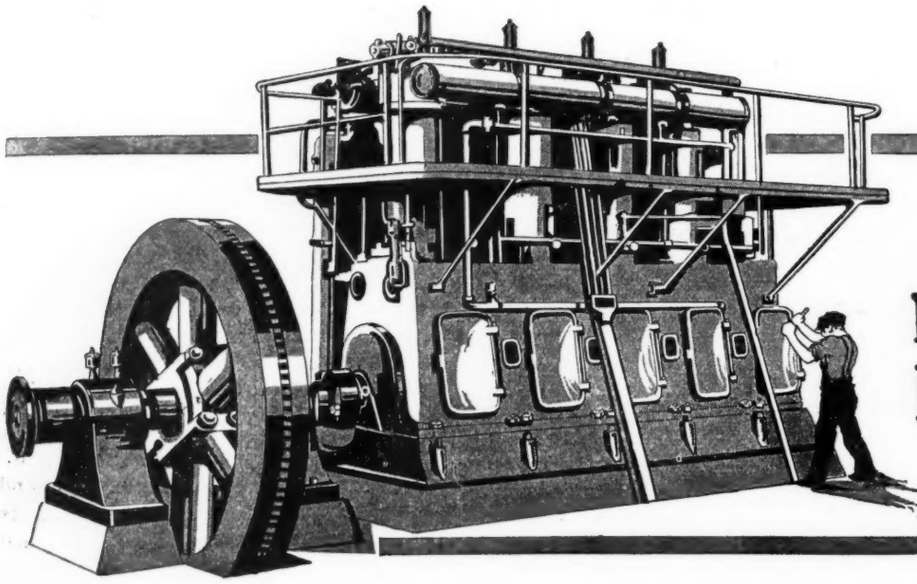


FIG. 14. DIAGRAMS OF RELAY AND TRANSFORMER CONNECTIONS FOR SERIES-TYPE RELAY TRIPPING CIRCUITS

According to the Bureau of Mines, volatile combustible containing a high percentage of oxygen appears to be more difficult to burn than that which has a low oxygen content. Whether this is due to the oxygen or to some other chemical property has not been determined.

When wood is used as a boiler fuel, the great problem is to reduce the excess air, because wood does not make a compact fire bed. Sawdust used with wood will aid in producing a more uniform thickness of fire.



Talks on DIESEL Engines

by L. H. Morrison

XV—The lubrication of crankshaft bearings, crank pins, piston pins, pistons and helical gears forms an interesting subject for the evening's discussion.

"DARN the cuss that invented chain oilers!" exclaimed Kelly with deep feeling. "I wish he'd strangled to death on his nursing bottle."

The silence of the rest indicated tacit approval of his sentiments. A main bearing on one of the 500-hp. engines had run hot that day and had to be rebabbitted, and the men were tired.

"Why are chain oilers used, anyway?" Kelly appealed to Egan. "I'd think a ring oiler'd be just as good, and it wouldn't break."

"To answer that demands a rehash of bearing lubrication," said Egan. "Many builders prefer a bearing with an oil cellar and one or two rings resting on the crankshaft. As the shaft turns, the rings draw oil up and deposit it on the shaft. This design is all right for shafts under 8 in. in diameter, but above that their use is objectionable."

"Chief," Woods interposed, "I'd think that the larger the shaft the more positive you'd be that the rings would revolve."

"The objection isn't due to the ring not revolving, but to the width of bearing," Egan explained. "With a shaft 9 in. in diameter, at least 6 in. of oil should touch the ring. Furthermore, the oil level can't be as high as the bottom bearing shell or it will leak out at the end of the bearing. The ring must drop at least 7 in. below the shaft, and with a 9-in. shaft this means a ring diameter of 16 in. So the bearing must be more than 16 in. wide to allow the ring to be inclosed. To avoid this, a brass chain is used. It not only calls for a minimum width of bearing, but draws up the oil faster. As we learned today, it has its objections, for it wears out and breaks. A brass chain is used rather than a steel chain because it saves wear on the shaft. But I blame Kelly somewhat for the hot bearing. He should have noticed that it was getting warm and run the oil hose from our storage tank on it. It's one of the few times Kelly has been caught asleep at the switch."

"Chief, what about the splash system?" inquired Woods.

"The splash system," Egan rejoined, "is probably all right on an automobile engine, but you can never be certain that the oilways are open. It may sound fishy, but at one of our plants a shaft bearing burned, even though the crank case was properly filled with oil. Someone left a bunch of waste on the bearing cap to keep out dirt while taking out a piston. If there had been some kind of stream lubrication, the lack of oil would have been discovered. Again, if an emulsion of water and oil is used, water may get into the bearing, and you know that a little water soon destroys any oil film on a rotating shaft.

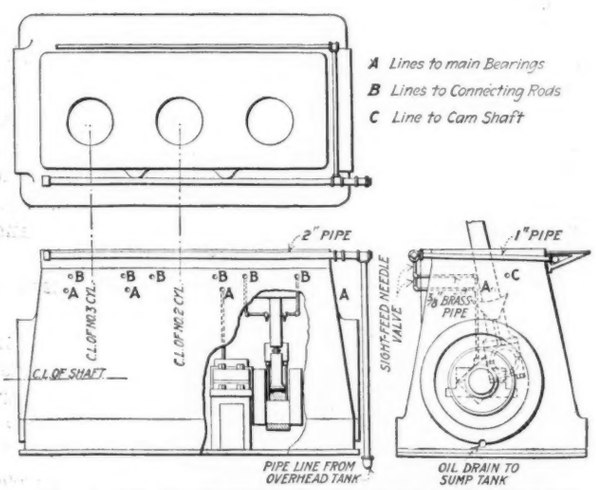


FIG. 1. ARRANGEMENT FOR STREAM LUBRICATION

"Furthermore, the splash system uses too much oil. We use two quarts of crank-case oil every two hours, or 6 gal. per day, on our 225-hp. engine, which means an average of 0.001 gal. per horsepower per hour. Compare this with one of our 500-hp. engines without splash lu-

At the next meeting the subjects of discussion will be fuel oils, filters and storage tanks

brication. Our records show 3.3 gal. of oil per day, and on a 20-hour run this equals 0.00033 gal. per horsepower per hour. Neither figure takes into account the oil for the air compressor, as that is about the same in the two engines."

"I notice that you throw away the oil each time we clean out a crank case," observed one of the men. "I should think the oil would be good to use."

"At first I thought the same," Egan confessed. "But

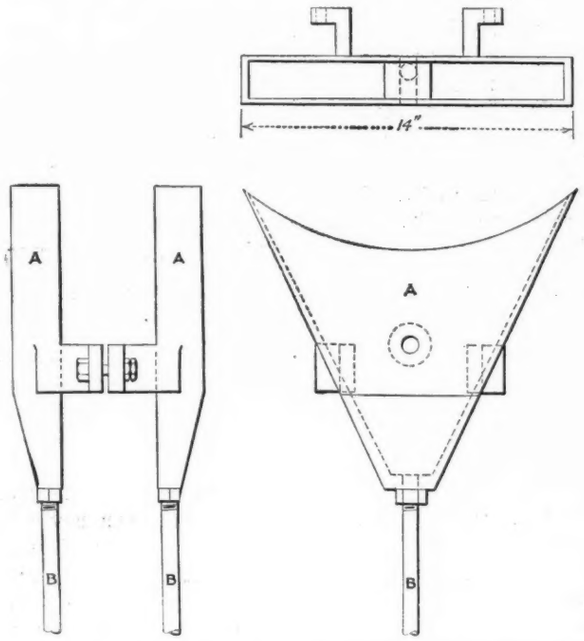


FIG. 2. DETAILS OF CONSTRUCTION OF OIL BOAT

it wasn't long before trouble with hot pistons and crankpins showed us our error. It's my experience that the crank case should be emptied every three months and the oil thrown away or else used on lineshafts, water-pump bearings and other places where a high-grade oil is not needed. The trouble with using this emulsified crank-case oil is that it contains water globules and so does not flow into oil grooves very readily."

"How much oil ought to be put in the crank case?" someone asked.

"Our practice is to put 8 gal. of oil in the pit under each crank and add enough water to bring the level about 2 in. above the bottom side of the crankpin when it is on bottom center. After the engine runs awhile, the emulsion of oil and water has a much higher level. You can get a good idea of the amount of oil in the case by putting your forefinger in the vent hole on the side door. After noting the feel of the oil as it strikes your finger, you should keep that degree of emulsion by adding water and oil at the necessary intervals. But this system is old-fashioned and it is profitable to change it to a system of stream lubrication.

"One of our plants that made such a change saved one-fourth of the oil bill and made the oiling more positive. Fig. 1 shows the arrangement. The oil was stored in an overhead tank and after going through the bearings, drained off to a filter in the basement, from which it flowed to a sump tank that was emptied once a day by a hand pump, the oil being discharged into the overhead tank again."

"I don't get the way the crankpin is oiled, chief," spoke up Kelly.

"We had aluminum oil boats or funnels, like those shown at *A*, Fig. 2, clamped together on opposite sides of the connecting-rod," said Egan. "The rod was tapped for two $\frac{3}{8}$-in. capscrews that passed through the boats and kept them from moving, and $\frac{1}{4}$-in. brass pipes *B* led to the brasses, which were tapped to receive the pipes. The length of the boats was such that the oil was caught no matter what position the connecting-rod was in."

"Well, how did they oil the piston and pin?" Woods inquired.

"A groove *A*, Fig. 3, was cut in the side of the piston and from the bottom of the groove a diagonal hole was drilled through the side of the piston. Into the hole was screwed a pipe *B*, the end of which was directly over the oil hole *C* in the connecting-rod and brass. A wavy groove was cut in the piston face, as shown in Fig. 4. Then three other holes were drilled through the water jacket, bushed, and fitted with check valves. The oil was injected by a small plunger pump connected to the needle-valve bell crank. Every time the needle valve was opened, the little pump squirted a shot of oil into the piston-pin oiler and the cylinder oilers. This oil injected onto the piston flowed along the groove and lubricated the entire circumference. It was a crude device, but it was cheap and satisfactory."

"Couldn't we use a scheme like that on our No. 1 engine with those chain-oiling main bearings?" asked Kelly, who had had enough of chains.

"I'm planning to do that very thing," Egan replied. "It will be simple. All the oil cellars are now connected by a common drain pipe; so I plan to put in a line of nickel-plated pipe with outlets to all the bearings. I'll use an overhead tank and run the drain lines direct to the filter, which we'll put in a pit."

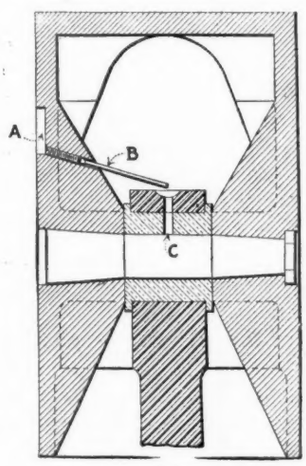


FIG. 3. METHOD OF LUBRICATING PISTON PIN

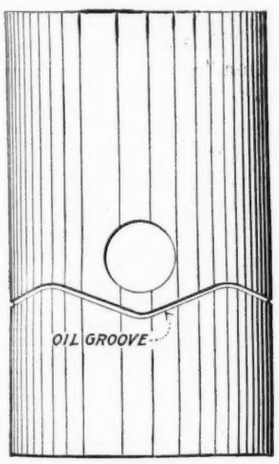


FIG. 4. LUBRICATION OF PISTON SURFACE

"Mr. Egan," Woods interrupted, "isn't a chain- or ring-oiled bearing O.K. if you use one of these mechanical oil pumps that lets a drop of oil run to the bearing ever so often?"

"I don't think so. Such a lubricator doesn't give enough oil to keep the temperature down, if a ring fails. So all it actually does is to furnish new oil to the oil cellar.

"Fig. 5 shows another oiling system. The mainshaft is drilled diagonally so that the pins may be oiled. The oil is handled by a rotary pump geared to the engine shaft. The oil line runs to the bottom of each bearing housing where it enters the bearing. Part of the oil enters the diagonal holes and thus oils the pins. The oil drips into the crank case, flows to the filter and oil cooler and then back to the pump.

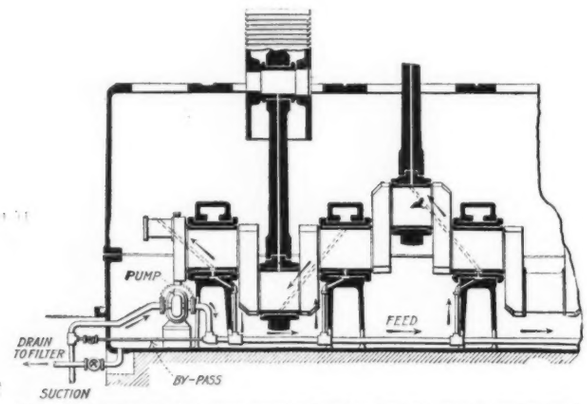


FIG. 5. DIAGRAM OF FORCED-LUBRICATION SYSTEM

"The advantage of this system is that the oil is forced into the bearing at the point of heaviest pressure. Consequently, lubrication is positive. There is no danger of the oil film being broken, as often happens with ring oilers. The pressure on the oil line as recommended by the builders is 15 lb., but we had better luck with 25 lb. The oil pressure is registered on a gage that furnishes an excellent way to learn if the bearings are getting oil. If the pressure runs up, it's plain that part of the pipe line is clogged or one of the bearings has got hot and stopped the port. If the pressure decreases, the filter may be dirty. A leak may have developed in the piping, the bypass may be leaking, or the oil may be escaping from the edge of the housing."

"What's the objection to this system?" asked Kelly, who always expected Egan to have some objection.

"The engine we use it on has water-cooled pistons, and the telescope tubes often leak, letting water get into the crank case and mix with the oil, causing hot bearings. So we put in a water separator made of a piece of 8-in. pipe with the drain pipe running into it, forming a trap, as shown in Fig. 6. I expect this to be drained of the accumulated water every day, but I have a hunch that you don't always do it."

The embarrassed laughter of the men was proof that the chief had guessed shrewdly.

"To lubricate a shaft bearing successfully by any oiling system, the oil must form a film and have low friction. Many oils that apparently are of proper viscosity and free from filler haven't enough cohesion to cover the shaft without breaking.

"Usually bearing oil receives less attention than cylinder oil. It's true that a cheaper oil can be used, but experience proves that bearing trouble is more prevalent than piston trouble.

"Now, let us consider piston lubrication. Almost all makes of engines use force-feed lubricators for oiling the cylinder walls. Many of these pumps are giving satisfactory service. Personally, I prefer the kind that is so geared that the oil is injected onto the piston surface when the piston is at the lower end of its stroke. In this way the oil is deposited on the piston when its temperature is fairly low. The piston with its film of oil lubricates the entire cylinder on the up stroke.

"It's practically impossible to get a suitable cylinder oil by specifying the flash point and viscosity. Personally, I believe in trying out an oil, and, if it works right, continue to use it. It must have enough body to seal the piston and rings and so prevent loss of compression, and it must burn without leaving a carbon deposit."

"Burn?" Kelly repeated wonderingly. "I always thought you wanted to use the oil to oil the piston and not to burn up."

"I've often been entertained by oil salesmen talking of the nonburning qualities of their oil," Egan replied dryly. "But the fact is that no oil on earth can be used in a cylinder of a Diesel engine without burning. On each power stroke the flame of the burning fuel charge absolutely consumes the film of lubricating oil on the cylinder walls."

"But, chief," Woods spoke up, "I've read that the average temperature in the cylinder isn't above 250 deg. F., and that isn't hot enough to burn lubricating oil."

"But we're dealing with maximum instead of average temperatures. I doubt that 250-deg. statement.

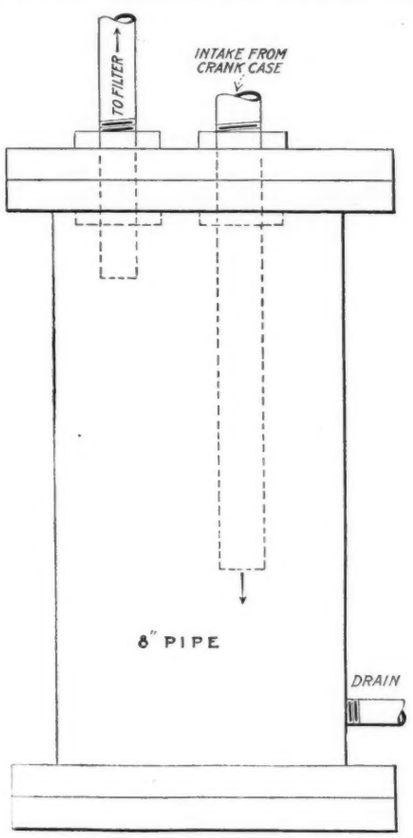


FIG. 6. HOME-MADE WATER SEPARATOR

Maybe the side of the cylinder walls in contact with the cooling water is that cool; but if you drilled a hole into the wall, you'd find the temperature running high enough to burn the oil. So we want a lubricating oil that will burn without leaving a carbon deposit. It must be strictly mineral, neutral and free from animal or vegetable oil, soap compound, mica, graphite or soapstone.

"The chief trouble I find with you fellows is your habit of playing safe by using too much cylinder oil. The proper way is to reduce the drops per minute, gradually until you are feeding just enough to keep the piston lubricated. If you use too much, carbon is bound to form and the rings will gum in the grooves and cut the cylinder."

"How much oil ought we to feed, then?" Kelly wanted to know.

"You will find our lubricators all adjusted to give about 6 drops per minute to the cylinder and 15 drops per minute to the piston pin. As to camshafts and valves, it's best to use the same oil as with the pistons. One of our engines had grease cups on the valve-lever bearings, but we had to change to wick oil cups. The grease wouldn't run until the bearings warmed up, which was a thing we wanted to prevent. With the valves, it's best to use a little kerosene every day and oil about every four hours. The kerosene prevents carbon forming from the oil."

"Chief, you promised one night to say something about oiling gears."

"I'd almost forgotten that, Woods. The trouble with helical gears is to get an oil that will maintain a film on the teeth. If the oil flows readily enough to form a film, it is likely to squeeze from between the teeth as they come in contact. And if it is viscous enough to keep from being thrown off by centrifugal force, it usually is too solid to form a film, acting more like a grease than an oil. The best way is to carry a high oil level in the gear case and have an oil cup that drops additional oil on the teeth where they come into contact."

Egan yawned, rose and stretched himself.

"Now, boys, let's hit the hay. It's hard days like this one that make me feel that soon the plant will need a new chief."

Brown Boiler-Room Signaling Pyrometer

Among other developments in boiler-room practice, engineers are giving attention to the regulation of firing by the temperature obtained in the furnace, boiler passes and uptake.

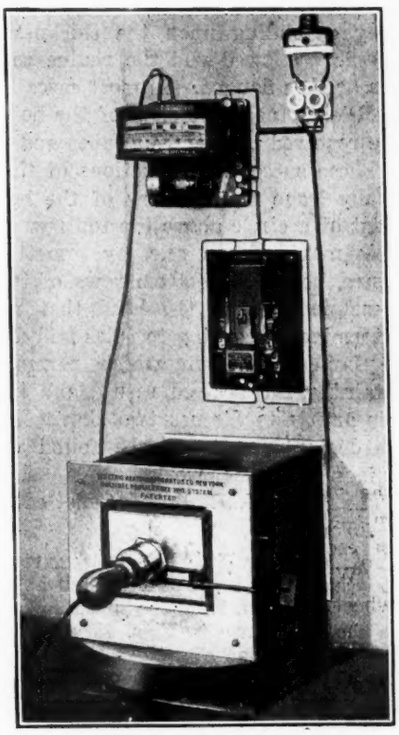
To indicate the boiler operation when the temperature is too high or too low, the Brown Instrument Co., Philadelphia, Penn., has developed a signaling pyrometer. Three lights are grouped for each furnace, a green light indicating that the temperature is too low, white that the proper temperature is being maintained, and red that the temperature is too high.

For instance, suppose the gases in the boiler uptake should run between 500 and 550 deg. F. with satisfactory firing conditions. If the temperature drops below 500 deg. the green light is automatically lighted, or if it exceeds 550 deg. it would show an excessive amount of heat passing up the chimney due to incompetent firing. The fireman having the group of three lights before him on the boiler, will endeavor to keep the white light burning by means of careful firing. The apparatus shown herewith operates automatically and is similar in construction to the ordinary indicating pyrometer.

A contact table adjustable throughout the whole scale range carries three contacts corresponding to the three lights, the central contact operating the white light, usually covering a space of 20 deg. on the scale, amounting to 10 deg. plus or minus the desired temperature. The pointer on the pyrometer is automatically depressed once a minute on the tungsten contacts.

An automatic three-position relay is operated by the closing of the contacts in the instrument. Assume that the furnace is started up and the low contact is closed, corresponding to the green light, and the relay completes the circuit through the green light. The contact in the instrument is closed only a few seconds to operate the relay, but the green light continues to burn until the temperature rises to the desired point, when the relay shifts, causing the white light to burn and extinguishing the green. The proper light continues to burn, although the contact in the instrument closes only for a few seconds once a minute.

It is frequently desirable to incorporate a hand-operated switch with the instrument so that the temperature of the thermocouple in a furnace may be automatically signaled and the temperature of other thermocouples may be read on the scale by some qualified official. This is easily handled.



SIGNALING PYROMETER

We will assume that the temperature of No. 1 thermocouple is to be signaled and the switch ordinarily remains on No. 1 point. It can be thrown by hand to Nos. 2, 3 or 4 points for instance, and when thrown the circuit through the lights is automatically cut off from the instrument, but the relay continues to maintain the light burning on No. 1 thermocouple until the other temperatures have been read and the switch returns by a spring to No. 1 position. Then if any change has taken place in the temperature while the other points were being read, the relay will automatically operate again.

By introducing an automatic motor or clock-driven switch in connection with a pyrometer, the temperature of practically any number of thermocouples can be automatically signaled by one instrument.

The cubic capacity of an 8-in. pipe line is about 328 bbl. of oil per mile. As the length of the principal pipe lines in the United States is over 30,000 miles, millions of barrels of oil are required simply to keep these lines in operation.

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Areas of Segments of Boiler Heads

By C. H. BERRY*

THE head of a boiler drum must be treated as a flat surface to be supported by either through or diagonal stays designed to carry the full load exerted against the head by the internal pressure. In the fire-tube boiler the tubes reduce the area to be stayed in two ways: First, each tube reduces the load to be supported by an amount equal to the internal pressure multiplied by the area of the tube hole in the boiler head; second, each tube is in itself an excellent stay, adequate to carry the load due to the pressure exerted against the adjacent portion of the head. Only in cases of exceptionally wide tube spacing are stays required among the tubes.

The shell of the boiler drum also acts as a stay and is able to take care of the pressure against an annular ring around the edge of the head, the width of this ring depending upon the thickness of the head, the pressure allowed and the radius to which the edge of the head is flanged. In most cases the tubes are spaced sufficiently near the shell of the boiler so that no stays are required between the tubes and the shell.

These successive reductions of the area to be stayed finally leave two sections of the head: One, the segment of a circle above the top row of tubes; the other, a segment of a circle, or sometimes a less regular figure, below the bottom rows of tubes. The areas of these portions of the head that require staying are determined according to rules laid down in the A. S. M. E. Boiler Code, in which formulas are given for obtaining the desired result, and it is the purpose of this article to discuss two charts by the use of which the desired results can be found without recourse to tedious numerical work.

The A. S. M. E. Boiler Code, edition of 1918, reads as follows:

214. Areas of Heads To Be Stayed. The area of a segment of a head to be stayed shall be the area inclosed by lines drawn 2 in. from the tubes and at a distance d from the shell as shown in Figs. 15 and 16. [Fig. 15 is given here as Fig. 1 and Fig. 16 as Fig. 2.] The value of d used may be the larger of the following values:

(1) d = the outer radius of the flange, not exceeding 8 times the thickness of the head.

(2) $d = \dfrac{5 \times T}{\sqrt{P}}$

where d = Unstayed distance from shell in inches;
T = Thickness of head in sixteenths of an inch;
P = Maximum allowable working pressure in pounds per square inch.

217. The net area to be stayed in a segment of a head may be determined by the following formula:

$$\frac{4(H - d - 2)^2}{3}\sqrt{\frac{2(R - d)}{(H - d - 2)}} - 0.608 = \textit{area to be stayed, sq. in.}$$

where
H = Distance from tubes to shell, inches;
d = Distance given by formula in Par. 214;
R = Radius of boiler head, inches.

218. When the portion of the head below the tubes in a horizontal return-tubular boiler is provided with a manhole opening, the flange of which is formed from the solid plate and turned inward to a depth of not less than three times the required thickness of the head, measured from the outside, the area to be stayed as indicated in Fig. 16 [Fig. 2 of this article] may be reduced by 100 sq.in. The surface around the manhole shall be supported by through stays with nuts inside and outside at the front head. The distance in the clear between the bodies of the braces, or of the inside braces where more than two are used, shall not be less than 10 in. at any point.

The two charts designated as Figs. 3 and 4 are intended to replace the two formulas quoted in Pars. 214 and 217. The chart in Fig. 3 gives the value of the allowance d, and that in Fig. 4 gives the area to be stayed. The first of these charts gives the value of the allowance d according to the formula, $d = \dfrac{5 \times T}{\sqrt{P}}$ as quoted from the A. S. M. E. rules. It will be noted that the rules state that d may be the larger of two values, either the outer radius of the flange or the value given by the formula. The rules further state that in taking d equal to the flange radius the value of d may not exceed 8 times the thickness of the head. On the other hand, there is no restriction on the value of d as given by the formula. This means simply that when the formula gives a value greater than 8 times the thickness of the head, d will be determined by the formula, regardless of the flange radius, and that when the formula gives smaller values, the flange radius must be taken into account. It is to be noted from the chart that the formula gives values greater than 8 times the head thickness only when the pressure is less than 100 lb. per sq.in. The value of the thickness T in the formula is taken in *sixteenths* of an inch, but in the chart, Fig. 3, this quantity is laid off on a scale of inches, divided into spaces representing thirty-seconds of an inch.

Before making use of the chart in Fig. 4, it is necessary to subtract the allowance d from the radius of the head (in inches), thus obtaining $(R - d)$, and also to subtract d from the distance H (in inches) between a line tangent to the top (or bottom) row of tubes and the boiler shell, thus obtaining $H - d$. With the two values thus obtained, the chart in Fig. 4 may be used to obtain the net area of the segment to be stayed, in square inches. An illustrative example, showing how the charts are used, is given on the page containing the charts.

If the area to be stayed is of the form shown in Fig. 2, it can be figured as the sum of the area of a segment, found with the aid of the charts, plus the area of a rectangle limited on one side by the chord of the segment and on the other sides by lines drawn 2 in. from the tubes.

Engineers and chemists have for many years decried the waste of burning raw bituminous coal. They have time and again shown that it is far more economical to break the coal up, by means of carbonization, into its constituent elements of solid carbon, gas, ammonia, oils and tars, thus releasing these several valuable products for use in their respective fields.

*Until recently assistant professor of heat power engineering, Cornell University.

EXPLANATION

1. Find the allowance **d**, which equals the larger of two values: either the outer Radius of the Flange, not to exceed 8 times the thickness of the Head, or the value given by the Chart, Fig. 3

2. From **R** subtract **d**
   From **H** subtract **d**

3. Find from the Chart, Fig. 4, the net Area to be braced.

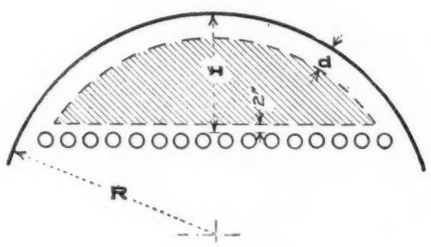


FIG. 1

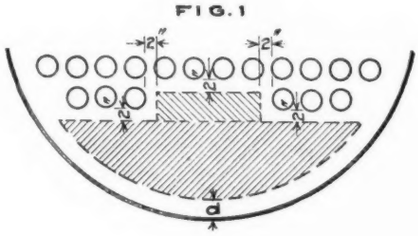


FIG. 2

EXAMPLE

Allowable Pressure	= 150 lb.
Thickness of Head	= ¾ in.
Radius of Head, **R**	= 48 "
Height, **H**	= 30 "
Allowance, **d**	= 4.9 "
R - **d**	= 43.1 "
H - **d**	= 25.1 "
Area of Segment	= 1256 sq. in.

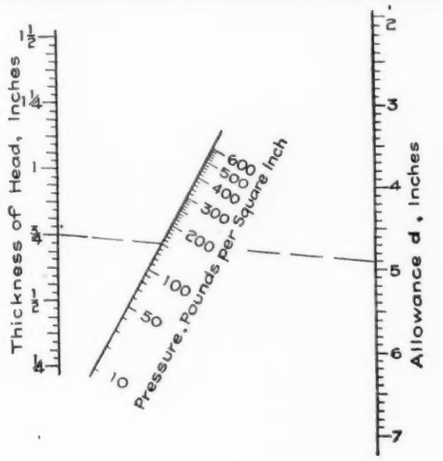


FIG. 3

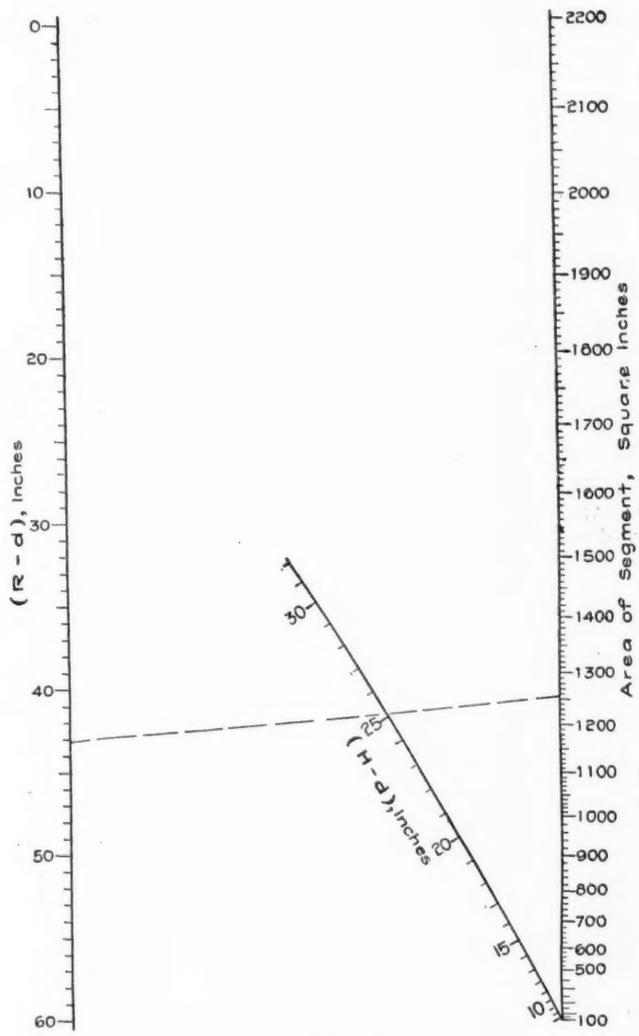


FIG. 4

C. H. BERRY, 10-30-1918

DIRECTIONS AND CHARTS FOR FINDING AREAS OF SEGMENTS OF BOILER HEADS

OPERATION at HOLTWOOD

By Charles H. Bromley

Holtwood (Near McCalls Ferry) is on the Susquehanna River about fifteen miles from Lancaster, Pennsylvania, and forty from Baltimore, Maryland. The station has hydraulic capacity of 118,500 horsepower in eight units with generators of 83,500 kilowatts rated capacity. It distributes at 70,000 volts.

Tells what causes may induce the governors of the hydraulic turbines to hunt and how to avoid or remove these causes. Great care is taken to insure adequate pressure of the fluid for the governor system. How operation of the turbine gates is continued should this pressure become reduced.

HUNTING comes about through a number of causes, chief of which are oversensitiveness, too light dashpot oil, lost motion in the governor-operating mechanism, needle valve on the dashpot improperly adjusted, and permitting too free a movement of the piston in the dashpot. Heavy swings of load may induce the governor to hunt. After an interruption of service cross-currents between generators usually aggravate governor troubles. Serious surging in the tailrace, which may make and break the vacuum in the draft tube, will cause the governor to hunt. Electrical hunting of the generators due to disturbances on the system or to a bad shot in synchronizing will lead to hunting of the turbine governors. The electrical hunting must be stopped. Excessive lost motion in the restoring mechanism also may cause hunting. Hunting can usually be stopped by adjusting the dashpot needle valve, which should never be more than one-quarter turn open.

Holding the pilot-valve stem by the hand in a fixed position tends to stop hunting. The valve stem must not have side pressure exerted upon it, as this may cause injury to the valve.

In rare cases all governors will hunt at the same time. When this occurs, as many attendants as possible are placed at each governor to hold the valve stem by hand until the water in the forebay and tailrace stops surging. Widely swinging loads, as Sunday or holiday railway loads, induce surges easier than the combined industrial, railway and lighting load on weekdays.

Stripped Governor Gears—Careful observation is kept for hot governor bearings, for if these seize, the gears will be stripped, the governor made inoperative and the wheel gates will assume their balanced position, approximately 50 per cent. gate opening. During peak load the unit is cut out if this happens. The machine is changed over to hand control and continued in service until repairs can be made.

The damaged turbine is never cut out suddenly, as this would likely result in frequency disturbance.

The governor-regulating valve should always respond to movement of the pilot valve. When it does not, the regulating valve is stuck. Grit or scale caught in the valve, or wiping of the valve against the seats due to poor lubricating quality of the governor fluid, or a split valve ring, will cause the regulating valve to stick. When it does stick, it must be taken out and the cause removed. When a hissing sound comes from the regulating valve, it is an indication of excessive leakage. Should the restoring mechanism break owing to excessive friction in the pins or to severe surges, the gov-

ernor is cut out and the machine continued in operation by hand control.

Supply of Pressure Fluid for Governor System—There are two separate systems of pressure supply lines, return headers, sump tanks, pumps, etc.: One, the governor control; the other, the hand-control system. Fa-

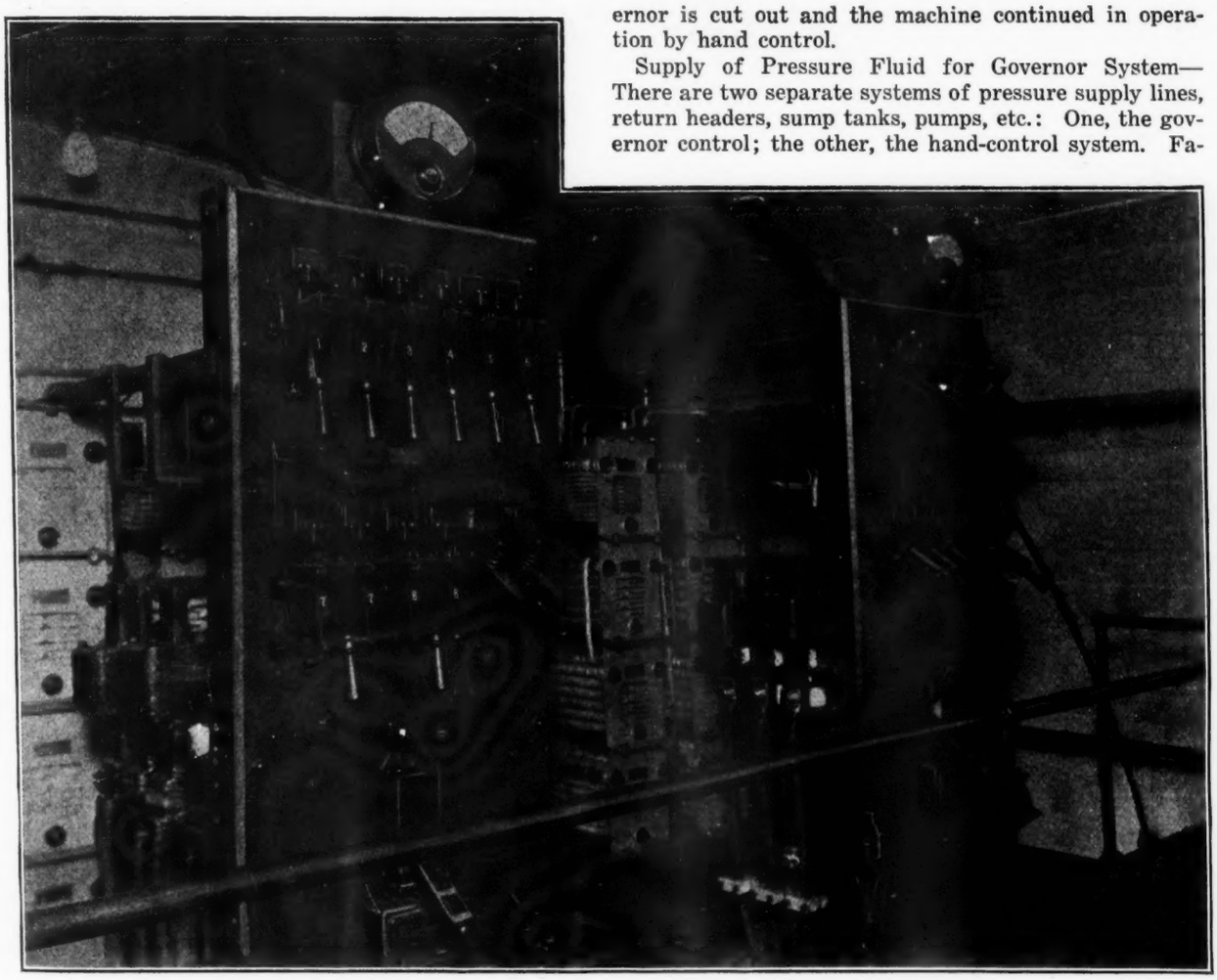


FIG. 1. SPEED-CONTROL PANELS FOR THE ALTERNATING-CURRENT MOTORS DRIVING GOVERNOR FLUID PRESSURE PUMPS

cilities for interconnection are provided, but normally the two systems are kept separated. There is a third gravity-pressure supply furnished by a concrete tank on the hill outside of the power house; this is used only in emergencies.

The governor-control system receives its pressure from four centrifugal pumps—two alternating-current-driven and two direct-current-driven. The hand control is supplied by a centrifugal direct-current-motor-driven pump and by a waterwheel-driven plunger pump. The motors of the alternating-current-driven governor pumps are arranged for variable speed, the adjustment of which is left to the care of the pumpman. This is accomplished by short-circuiting resistances connected in the slip-ring rotor circuit.

The direct-current driven pumps are started up automatically by contact-making pressure gages set for 240 lb. (see Fig. 3). This gage is mounted on the same panel with the solenoid-operated starting switches located near the pumps on the tunnel floor. The standard pressure gage shown on the illustration to the left of the panel is used in connection with the daily routine check made on the automatic starting feature of these pumps.

If the alternating-current power supply should fail temporarily, the alternating-current-driven pumps would slow down and both direct-current-driven pumps would come quickly into action. For a short time the pressure fluid stored in the accumulators, located on the thrust deck of each unit, could continue to operate the gate cylinders to the equivalent of four full strokes of the piston. The power supply to these motors is assured by the waterwheel-driven exciters and by a large emergency storage battery that would discharge automatically into the direct-current service connections in case the exciters should be disabled temporarily.

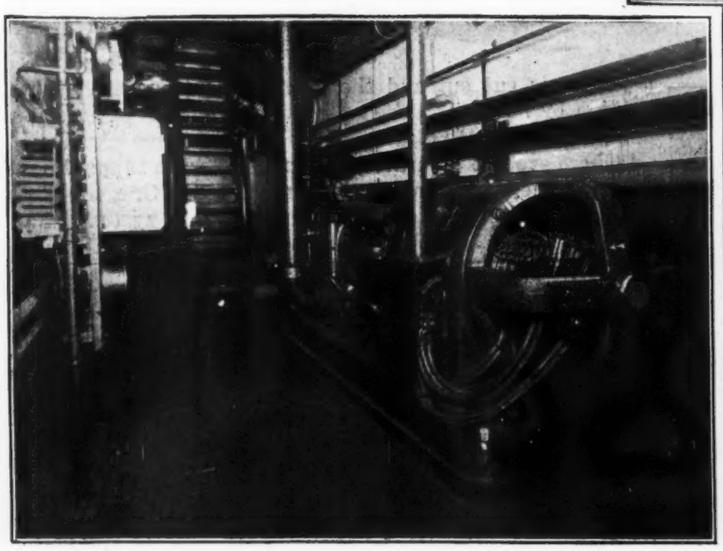


FIG. 2. DIRECT-CURRENT GOVERNOR PUMP SET

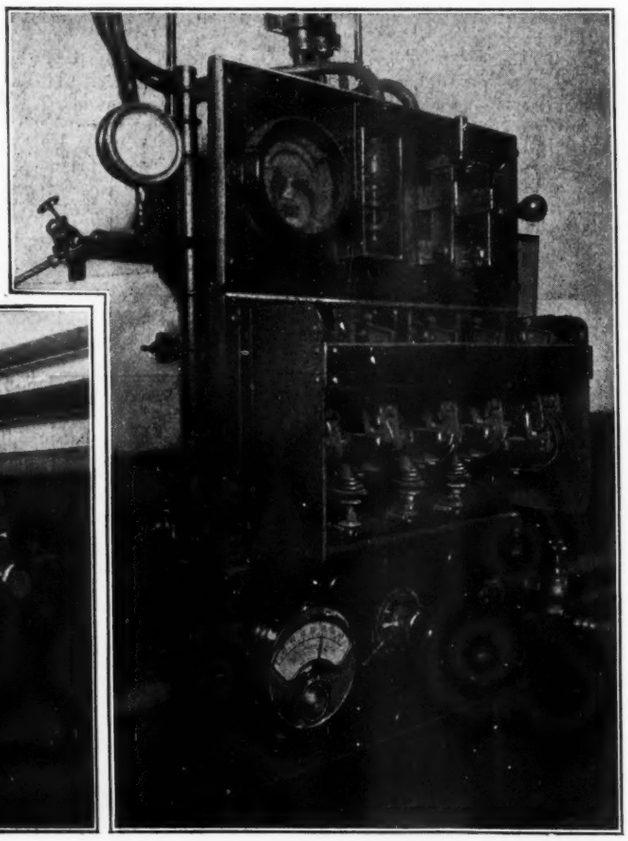


FIG. 3. AUTOMATIC STARTING PANEL FOR DIRECT-CURRENT DRIVEN GOVERNOR PUMPS ENERGIZED BY CONTACT-MAKING PRESSURE GAGE

High-Pressure Accumulator Air—This air is normally at 330 lb. per sq.in.; it is supplied by two air compressors (see Fig. 5). Should both compressors go out of service from any cause, the high-pressure air is obtained by filling one of the accumulator tanks with atmospheric air, or air at 100 lb. pressure, which usually is available, and building up the pressure by forcing water from the central pumping system into the accumulator. The pressure can thus be increased above the pressure in other accumulators, and it may be transferred to them through the pipe connections. The process must be repeated as many times as may be necessary to produce the required compression.

For the remote contingency that the entire pumping system should fail, the fluid may be completely drawn from the accumulator tanks and the compressed air in the tanks may escape through the governor valves. The first step, of course, is to restore the air pressure. The operator has his mind prepared for such a contingency and would resort to the air in the accumulator tanks of such units, which are not in service and which can be used to refill the tanks in which the pressure has been lost. Service may be more quickly restored by starting a unit that has been shut down, as its accumulator has the normal air pressure.

Sometimes, when the pressure is insufficient to move the wheel gates, closing the supply valves on units out of service will reduce leakage sufficiently to permit the necessary pressure to be built up.

Emergency Pumps on the Governor-Control System—There is a pump known at the plant as the Hill pump because it forces water to a tank on "the hill," which is near the station, the tank being at an elevation of 320 ft. from the pump. In the event of complete failure of the governor system and the hand-control system, "hill" pressure is admitted automatically through a check valve to the hand-control system, this water coming through the white, or filtered, water pipes connected to the hill pressure system.

To protect even against the contingency of loss of

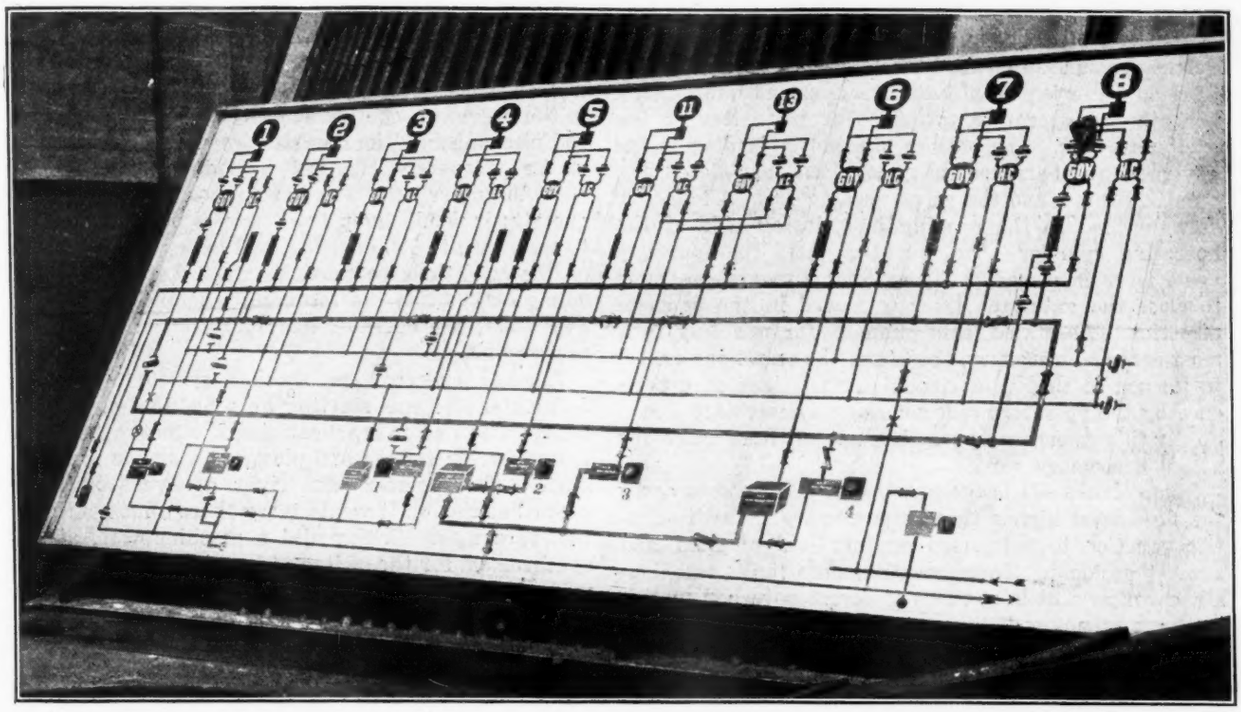
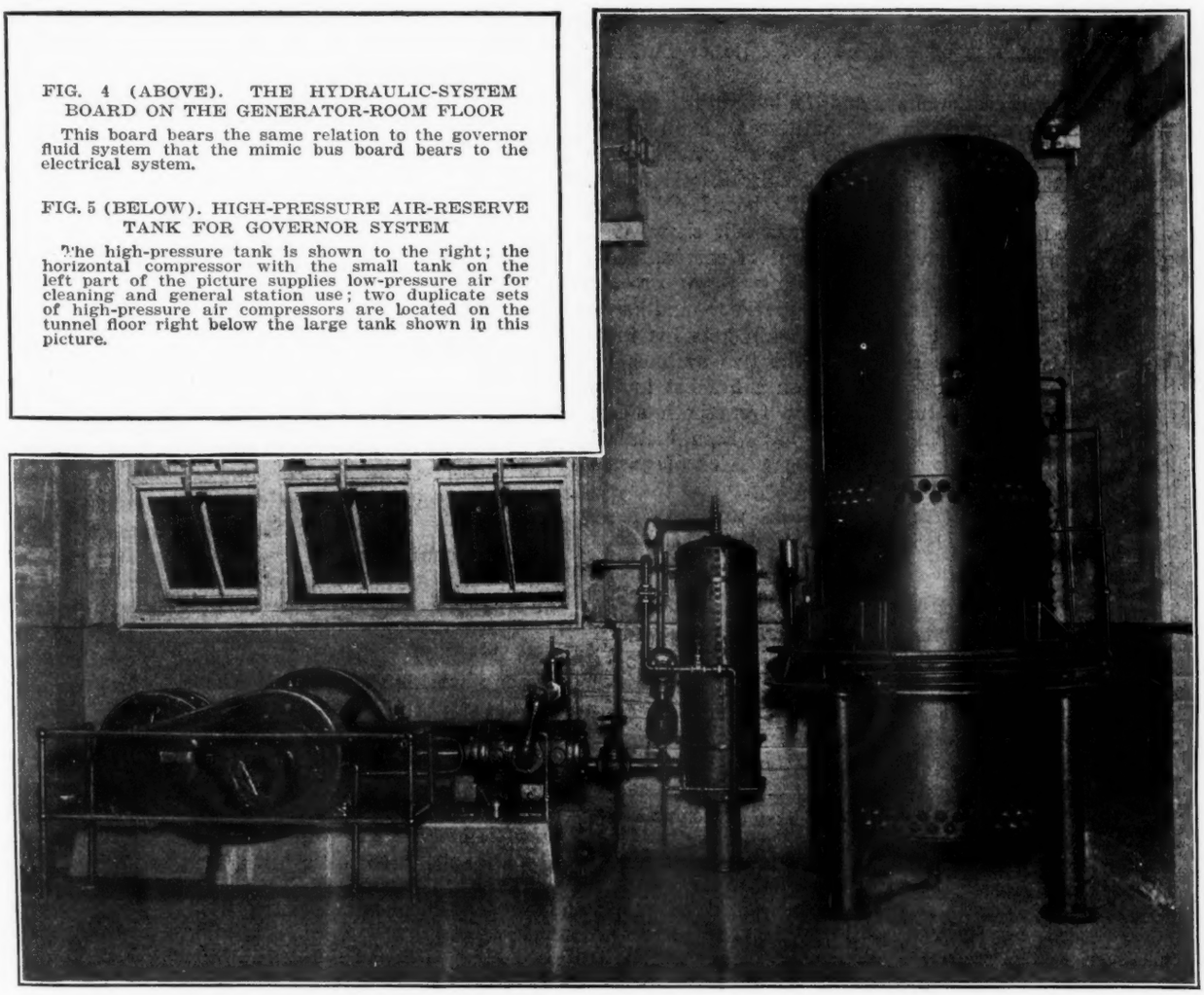


FIG. 4 (ABOVE). THE HYDRAULIC-SYSTEM BOARD ON THE GENERATOR-ROOM FLOOR

This board bears the same relation to the governor fluid system that the mimic bus board bears to the electrical system.

FIG. 5 (BELOW). HIGH-PRESSURE AIR-RESERVE TANK FOR GOVERNOR SYSTEM

The high-pressure tank is shown to the right; the horizontal compressor with the small tank on the left part of the picture supplies low-pressure air for cleaning and general station use; two duplicate sets of high-pressure air compressors are located on the tunnel floor right below the large tank shown in this picture.



hill pressure, provision is made for quickly putting into service a small double-acting hand pump, producing sufficient pressure to operate the exciter gates. A bucket of clean water is poured into the sump tank immediately beneath the operating cylinder for the gates of the exciter turbine. The balance pipe valves leading to the governor- and hand-control systems are then closed, the pump operated, and the valves leading from a four-way valve opened to the opening and closing side of the operating cylinder. To open the gates the four-way valve lever is moved to its extreme forward position; to close the gates the lever is moved in the opposite direction. As stated, this pump is for use only in a most serious emergency, therefore, the crews are drilled in its use so that when trouble arises, lack of experience by the operators will not cause unnecessary delay. So far this emergency pump had not yet been called for actual emergency work.

Sump Tanks—It is the practice at Holtwood to carry the fluid level higher than is customary in hydro-electric practice to safeguard against loss of fluid and against accident. Therefore the sump tanks occasionally overflow a little at times of severe governor surges.

Severe pumping disturbances tend to clog the screens on the pump sections. This is indicated by an increased vacuum shown by a gage on the suction side. The screens are immediately cleaned.

Causes of Loss of Governor Pressure—This may be due to loss of alternating-current power, loss of direct-current power, loss of both, loss of fluid or bursting of the fluid piping.

The piping is sectionalized and the hydraulic and electric operating attendants are familiar with all valves opened or closed at any particular time from the position of the indicators on the hydraulic mimic board. The telltale lamps on this hydraulic board (Fig. 4), visible from the benchboard gallery, will show at a glance which pumps have dropped out of service. The operator can observe, also, recording gages on the benchboard platform that show the governor- and hand-control pressures. The pumpman again gets his indication of the pressure section in the two systems by large-dial pressure gages mounted on a bracket in the center section of the tunnel, visible from both sides. These different indicating devices have been installed for the specific purpose of permitting a quick diagnosis of trouble in the governor-pressure system, so that attendants can restore normal condition with the least possible delay.

Don't Take Chances with the Synchronoscope

By F. Gillooly

Modern tendency in power-station design is to separate the control room from the generating equipment, at the same time increasing the number of the instruments used. Therefore the operator must become more familiar with his instruments, reading more from them than is printed on their dials, when operating the station from them alone.

With the large generating units now being used, the synchronoscope becomes a most important instrument, and it should be studied carefully by the operator. Only from long experience and close study results a thorough familiarity that enables one to correctly interpret the reading of instruments.

I once strolled in on an operator who was synchronizing a 1000-kv.-a. alternator. The plant was old; each of the engine-driven generators had its belted exciter and was controlled by hand-operated oil switches located in the basement, operated through a long, many-jointed rod mechanism. The operator was not sure of himself, as he frequently changed his mind when about to close the oil-switch. The synchronoscope was behaving queerly; it would jump from zero to 90 deg. slow, back to zero, then to 180 deg. fast and back to zero. A check on the conditions revealed the fact that while the bus voltage was 6000, the incoming machine's voltage was only 1000; the operator had forgotten to build up the exciter voltage.

Another operator on another system was not so fortunate. He was starting up a 9000-kv.-a. frequency changer, and after synchronizing the motor, he checked the generator voltage and plugged in on the synchronoscope. The pointer was right at synchronism and seemed as though it would tarry there a moment, which was rare luck. Seldom did a machine wait at exact synchronism for the switch to be closed. The oil switch was of the motor-operated type; the operator pushed the control button, and in went the switch.

For a moment he was not sure whether he had operated an oil switch or discharged a ton of dynamite. The oil switch tripped out with a flash and a roar; half a dozen coils in the armature were burned out, the lamination was melted, the field coils were damaged, the shields over the end of the stator coils were broken off and sucked into the machine by the magnetic field, then hurled in pieces against the wall and through the windows. Had the operator investigated why the synchronoscope's pointer did not move, he would have found that the generator's potential transformer fuses were out.

Another avoidable error was made by an operator when he tried to put in a 4000-kv.-a. turbine unit and could not get the synchronoscope to work. Investigation showed the synchronoscope selector-switch open, and after closing it, he hurried on with the synchronizing. As soon as the oil switch was closed it tripped; the load on the station dropped as the synchronous apparatus kicked out of step all over the system.

The dust quickly disappeared from the machine, which was let run at full speed and voltage. The operator found the machine's voltage even with that of the bus and the frequency the same, and decided that the oil switch must have been slow to close. He synchronized again with as disastrous results. On doing what he had neglected to do in the beginning—to check the synchronoscope—it was found at zero when the lamps were bright and at 180 deg. when the lamps were dark. The trouble was found to be caused by someone working on the synchronoscope during the day and not testing it afterward. These experiences indicate the necessity of checking the synchronoscope before paralleling alternators.

Under Section 91 of the New York Labor Law, supervision of steam boilers by the factory inspector applied only to boilers in factories. The Bewley Bill, just passed the legislature and been signed by the Governor, calls for the inspection of all boilers carrying pressures over 15 lb. per sq.in. in all classes and types of buildings.

Add your mite to America's might—Buy Victory Liberty Notes—Buy before the sun goes down.

The Electrical Study Course—Current Division in a Three-Wire Generator

Explains in detail how the unbalanced current of a three-wire system divides among the armature windings of the three-wire generator.

IN THE preceding lesson the path of the current in the neutral wire of an unbalanced three-wire system was traced through the inductances used with a three-wire generator. The next step is to investigate the path of the currents from all parts of the system through the armature winding. For this purpose a numerical example will be found convenient.

In Fig. 1 G is the armature of a three-wire generator supplying current to a three-wire system as shown. Suppose that the load X between A and N is composed of 100 lamps, each taking one ampere at 110 volts, and that the load Y between N and B is composed of 60 such lamps. Then the current in A would be $100 \times 1 = 100$ amperes and that in B $60 \times 1 = 60$ amperes. The neutral N would carry the difference, or $100 - 60 = 40$ amperes. Since brush a is positive and brush b negative, the directions of the currents will be those indicated by the arrows. Upon reaching g the 40 amperes through N will have two paths to the armature, one through the inductance L_1 and the other through L_2 as explained in the preceding lesson. Having passed through L_1 and L_2, it continues through the armature to a. If the load Y were to be made larger than X, the current in N would flow from left to right instead of from right to left as shown, and the currents in the inductances would in that case flow in directions opposite those they previously had; namely, toward g instead of away from it. Just how the currents divide in the armature in either case will be made clearer by reference to Fig. 2.

Let us first assume that the load is balanced, each side of the system carrying 100 amperes, under which conditions there will be no current in the neutral and consequently none in L_1 and L_2 other than the alternating current through them. Consider this current to be 5 amperes for the position shown in Fig. 2. This makes a total of $100 + 5 = 105$ amperes going in at the negative point of the armature winding. The two halves of the generator's armature to the right and left of the brushes will each deliver half of the total load current, or $105 \times 0.5 = 52.5$ amperes. The direction of the current through the armature will be from the negative brush b to the positive one a, as shown by the arrowheads.

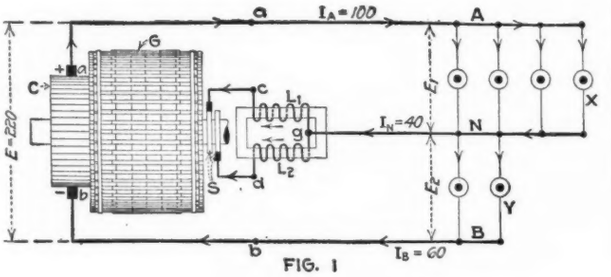


FIG. 1

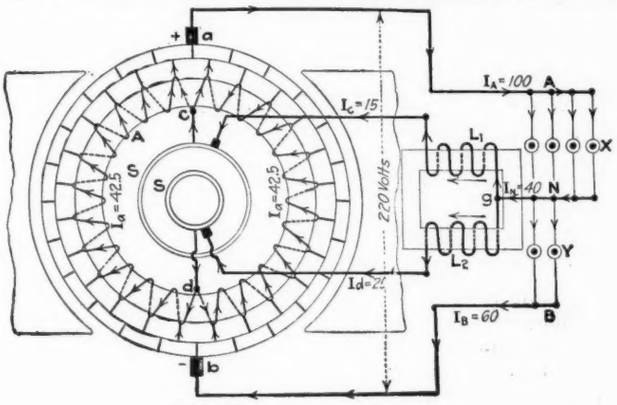


FIG. 3

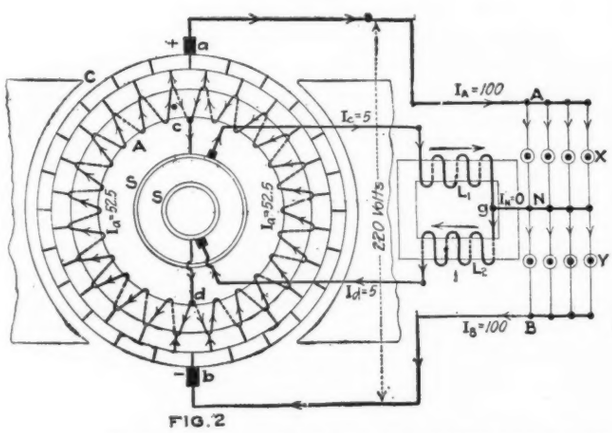


FIG. 2

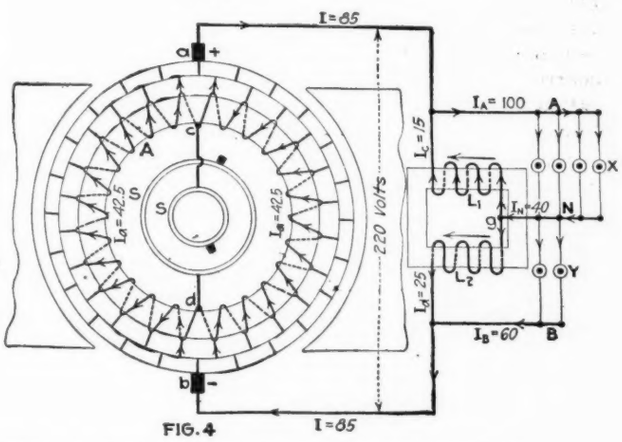


FIG. 4

FIGS. 1 TO 4. DIAGRAMS OF THREE-WIRE GENERATORS SHOWING DISTRIBUTION OF CURRENT

Suppose that the load is now unbalanced as in Fig. 3; that is, the load at X is 100 amperes and the load Y 60 amperes, causing a current of 40 amperes to flow in the neutral. It will be noticed that while the current leaving the brush a is 100 amperes, that entering the brush b is only 60 amperes, the difference being ac-

counted for by the 40 amperes that flow from the neutral through the inductances and finally to the armature. The 60 amperes flowing from Y split at the brush b, half passing through each half of the armature winding to the right and left of the brushes a and b, as indicated.

In the last lesson it was shown how, if the exciting current in the inductances was 5 amperes, with the armature in the position in Fig. 3, then when 10 amperes was flowing in the neutral all the excitation for

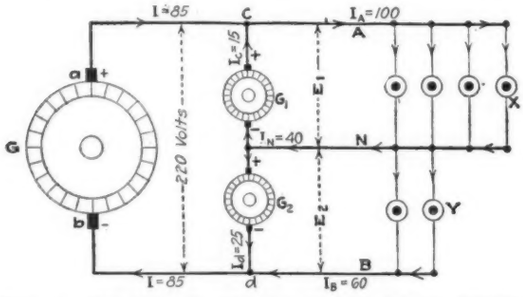


FIG. 5. BALANCER SET ON THREE-WIRE SYSTEM

the inductances would be supplied by one inductance; how, when the armature was in the position shown in the figure, L_2 would be supplying all the ampere-turns, and when the current in the neutral increased above 10 amperes, the increase divided equally between L_1 and L_2. Therefore, in Fig. 3, 10 amperes of the 40 in the neutral will flow through L_2 to supply the ampere-turns and the remaining 30 will divide 15 through L_1 and 15 through L_2, making a total of 15 amperes in L_1 and 25 amperes in L_2. The 25 amperes flowing through L_2 enters the armature winding at d and divides, 12.5 amperes flowing through the winding to the right of brushes b and a and 12.5 amperes to the left, making a total of $30 + 12.5 = 42.5$ amperes flowing in each half of the armature, or a total of $42.5 + 42.5 = 85$ amperes. This, added to the 15 amperes delivered by L_1, makes a total of $85 + 15 = 100$ amperes, leaving the positive brush as indicated. The next thing is to investigate the power distribution in the system. The entire load on the generator is the sum of the loads X and Y and the excitation required by the inductances L_1 and L_2.

Since the current in X is 100 amperes and the voltage across it is 110 volts, we have $X = 100 \times 110 = 11{,}000$ watts. Similarly, $Y = 60 \times 110 = 6600$ watts, and the watts taken by L_1 and L_2 at the instant shown in the 5×220 or $10 \times 110 = 1100$, making the total load that the generator has to supply equal to $11{,}000 + 6600 + 1100 = 18{,}700$ watts. The total current flowing in the armature is $42.5 + 42.5 = 85$ amperes; this value times the voltage gives the load supplied by the armature, equals $85 \times 220 = 18{,}700$ watts, which checks with the sum of the component loads on the external circuit.

In looking at Fig. 3, at first thought it might appear that the 15 amperes through L_1 should be considered in the current supplied by the armature; the fact is, however, that this current is not supplied from the armature, but is 220-volt power supplied to the system by the armature and is transformed into 110-volt power through the medium of the inductances. This will be more readily understood by referring to Fig. 4. At the instant shown in Fig. 3, if the inductances were disconnected from the brushes on the slip rings and connected across the line as in Fig. 4, the conditions would be identically alike except that the current flowing through L_1 would not pass through brush a. The current in the armature (60 amperes from load Y and 25 amperes through L_2), that is, $I = I^B + I_d = 60 + 25 = 85$ amperes. This gives the total power supplied by the generator equaling $EI = 220 \times 85 = 18{,}700$ watts, which check up against the lamp load of 17,600 watts, plus the power required by L_1 and L_2 at this instant, to excite them, of 5×220 or $10 \times 110 = 1100$ watts or a total of $17{,}600 + 1100 = 18{,}700$.

Comparing Figs. 3 and 4 with Fig. 5, the last representing a three-wire system obtained from a 220-volt generator G and a balancer set G_1 and G_2, it will be seen that all three are alike. The balancer set has been assumed to take 5 amperes at 220 volts to drive it without any load. As explained in previous lessons, the current division in this case would be as indicated in the figure, which is identical to that in a three-wire generator. In Fig. 5 the load on the generator is $W = 220 \times 85 = 18{,}700$ watts, and the system load is $X + Y = I_A E_1 + I_B E_2 = 100 \times 110 + 60 \times 110 = 17{,}600$ watts. To this must be added the 5 amperes at 220 or 10 amperes at 110 volts required to drive the balancer set, or 1100 watts, making a total load on this external system of $17{,}600 + 1100 = 18{,}700$ watts.

If the armature, Fig. 3, is turned through one-quarter revolution, it will be in the position shown in Fig. 6. As has been shown in previous lessons, no voltage exists across points c and d when the armature is in this position; therefore no exciting current will flow in the inductances L_1 and L_2, and the neutral current will divide equally between them; that is, 20 amperes will flow through L_1, entering the armature winding at c, halfway between brushes a and b, and 20 amperes through L_2, entering the right-hand half of armature at d, halfway between the brushes a and b. The 60 amperes in B enters the armature winding at the negative brush b and divides equally, 30 amperes going through each half of the winding. At points c and d

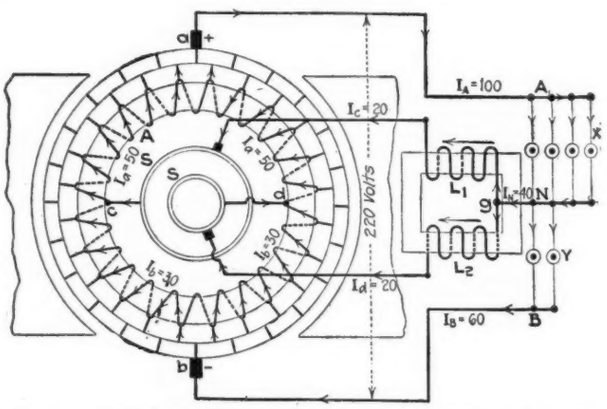


FIG. 6. THREE-WIRE GENERATOR ARMATURE LOCATED ONE-QUARTER REVOLUTION FROM THAT IN FIG. 3

these currents combine with the 20 amperes through L_1 and L_2, making a total current of $30 + 20 = 50$ amperes in the winding above points c and d, giving a distribution of the current as shown in the figure.

The load supplied by the generator at this instant is that at X and Y only, since the inductances do not take any power at the instant shown in Fig. 6. As has already been shown, the lamps at X and Y take $160 \times 110 = 17{,}600$ watts. The load on the armature may be looked at two ways; namely, 100 amperes at 110 volts,

on the half of the winding above *c d*, plus 60 amperes at 110 volts on the half of the winding below *c d*, making a total of 160 amperes at 110 volts; or that the half of the armature above *c d* is carrying 50 amperes at 220 volts, and the part below *c d* 30 amperes at 220, making a total of 50 + 30 amperes at 220 volts. This gives 160 × 110, or 80 × 220 = 17,600 watts in either case, therefore the watts developed in the windings equal the watts supplied to the load, which is as it should be, of course neglecting the losses in the machine, which have not been considered in any of the discussions.

It will be seen from this discussion that although the current may have different values in different parts of the armature, it is balanced in the parts to the right and left of the brushes *a b*. The general statement can be made that the ampere-conductors (amperes times conductors) to the right and left of brushes *a b* must always be equal, so as to make the available voltage in each half of the armature winding equal.

From the foregoing it is evident that the inductances differ from the balancer set in that the latter takes a certain amount of power from the generator continuously, as long as it is connected to the line, while the

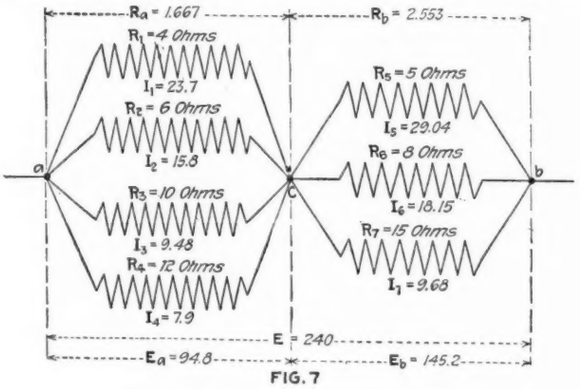


FIG. 7

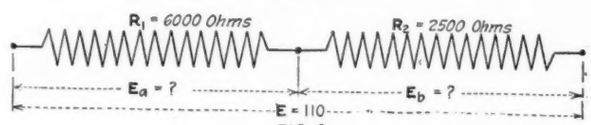


FIG. 8

FIGS. 7 AND 8. RESISTANCE CONNECTIONS

inductances take a maximum power when the armature is in the position shown in Figs. 2 and 3, and decreasing to zero when the armature is in the position shown in Fig 6.

In the problem of the preceding lesson it was required to compute the value of the current flowing through each of seven resistances arranged as in Fig. 7, if a voltage of 240 volts were applied to them across *a b*. Since R_1, R_2, R_3 and R_4 are in parallel, their joint resistance is $R_a = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}} = \frac{1}{\frac{1}{4}+\frac{1}{6}+\frac{1}{10}+\frac{1}{12}}$ = 1.667 ohms, and the joint resistance of R_5, R_6 and R_7 in parallel is $R_b = \frac{1}{\frac{1}{R_5}+\frac{1}{R_6}+\frac{1}{R_7}} = \frac{1}{\frac{1}{5}+\frac{1}{8}+\frac{1}{15}} = 2.553$ ohms.

The total resistance of the circuit is $R = R_a + R_b$ = 1.667 + 2.553 = 4.22 ohms. Let I equal the total current, then we have $I = \frac{E}{R} = \frac{240}{4.22} = 56.87$ amperes. From this the following relations can be determined: $E_a = I \times R_a = 56.87 \times 1.667 = 94.8$ volts, and $E_b = I \times R_b = 56.87 \times 2.553 = 145.2$ volts. To check our calculation we may add E_a and E_b and see whether the result is 240 volts. Thus, $E_a + E_b = 94.8 + 145.2 = 240$ volts, as it should be. In each case the current would be equal to the voltage across the resistance divided by its resistance in ohms. Since R_1, R_2, R_3 and R_4 are all connected between *a* and *c*, they all have the same voltage across them; namely, $E_a = 94.8$ volts. Likewise the voltage across R_5, R_6 and R_7 is the voltage across *cb* or $E_b = 145.2$. Let the current through R_1 be represented by I_1, that through R_2 by I_2 and so on. We then have

$I_1 = \frac{E_a}{R_1} = \frac{94.8}{4} = 23.7$ amperes, and similarly $I_2 = \frac{E_a}{R_2} = \frac{94.8}{6} = 15.8$ amperes, $I_3 = \frac{E_a}{R_3} = \frac{94.8}{10} = 9.48$ amperes, $I_4 = \frac{E_a}{R_4} = \frac{94.8}{12} = 7.9$ amperes, $I_5 = \frac{E_b}{R_5} = \frac{145.2}{5} = 29.04$ amperes, $I_6 = \frac{E_b}{R_6} = \frac{145.2}{8}$ 18.15 amperes, and $I_7 = \frac{E_b}{R_7} = \frac{145.2}{15} = 9.68$ amperes. These results may be checked by adding I_1, I_2, I_3 and I_4, and comparing with the sum of I_5, I_6 and I_7. The two should be the same and should be equal to the total current I, or 56.87 amperes. Making the additions, we have, 23.7 + 15.8 + 9.48 + 7.9 = 56.88 and 29.04 + 18.15 + 9.68 = 56.87. The former is seen to be 0.01 ampere too great, but the slight difference is accounted for by the fact that the decimals in the computations were not carried out to very many places.

Two resistances R_1 and R_2 of 6000 ohms and 2500 ohms resistance respectively are connected in series across 110 volts as shown in Fig. 8. What is the voltage across each of them? If a voltmeter whose resistance is 14,372 ohms were to be connected across R_1, what voltage would it indicate? What voltage would it indicate if connected across R_2?

Representing Capacity of Equipment

In the late case of Merkle-Hines Machinery Co. vs. Gaynor, 170 Northwestern Reporter, 381, the Iowa Supreme Court laid down the following rules of law applicable to sales of power equipment where the salesman makes representations concerning the capacity of the same:

A statement that second-hand steam-turbine generators are "in first-class condition and will carry the same guaranty as a new machine, as neither of them have been run to exceed six months," amounts to a warranty of the condition of the equipment and not merely to the expression of such opinion, commonly known as "dealer's talk," as is not actionable, the buyer having had no opportunity to inspect the generators before delivery.

An undertaking on the part of a seller that equipment is "of the full capacity, efficiency, and other qualifications stated in the attached specifications," and that the seller "agrees to correct any defects which may develop within one year," is not a mere agreement to replace defective parts, but constitutes the basis of a damage claim on the representation proving to be false.

Put another service star on your pocketbook. Buy Victory Liberty Notes.

Belted Motors and Group Drives

By W. H. Wakeman

Some engineers advocate the use of a motor for each machine in the shop or factory, regardless of the size required, and others favor the group drive as the most convenient and efficient. In many cases it is possible that a combination of the two systems will give the best results. When several small machines are located in various parts of a shop, it becomes necessary to provide a motor for each, even if some of them are but one horsepower capacity, and small motors are less efficient than one large enough to drive them all. If machines can be placed close together and driven by a single motor, the first cost will be less and the expense of operation will be more satisfactory.

To illustrate this point, Fig. 1 shows a comparatively high-speed motor hung from the ceiling, and as the machines to be driven run at low speed, two belt-driven countershafts are used. The three machines are set in line and connected by a chain-and-sprocket drive. The first is driven by a belt running at an angle of 45 deg., which is the right position for good results.

When a score of motors were to be installed at my plant, I did not allow them to be hung from the ceiling, but all were set on the floor or on platforms hung from the ceiling or anchored to the brick wall. Those that are on the floor are in the cooler part of the room

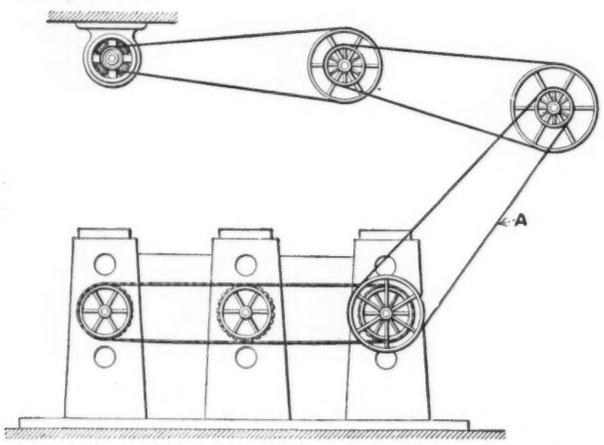


FIG. 1. MOTOR DRIVING TWO COUNTERSHAFTS

and are always convenient for care and adjustment. Those that are on platforms are not in the warmer part of the room, and it is not a difficult matter to reach them for cleaning and oiling.

Referring to Fig. 1, if instead of the belt *A* there had been a chain-and-sprocket drive, a more positive drive would have been obtained. If a machine is designed to run at, say, 300 r.p.m., then that speed should be maintained. Should the belt slip on the driving pulley until the speed of the driven machine is reduced to 270, the output would be 10 per cent. less than it ought to be, although the expense of operation would remain the same as when full speed was maintained. Although a belt will give full speed to the driven machine if it is wide enough for the load, a chain-and-sprocket drive for light work and a silent-chain drive for heavy loads are always reliable in this respect; they are best adapted to low speeds.

Although Fig. 2 shows but one machine in operation, it represents a group drive. The motor is reversed and is bolted to the ceiling. On the countershaft is a large pulley *A* for reducing the speed. This countershaft is used to drive another machine, not shown. Another belt carries power to the second countershaft *B*. The pulley *C* is on a shaft that transmits power to another machine. Of course the load is light,

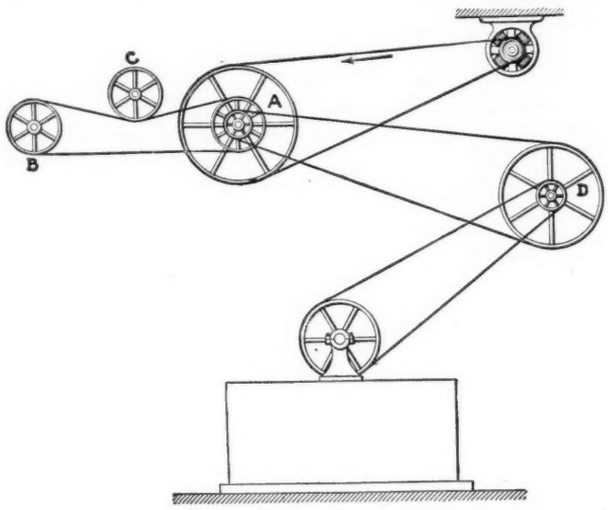


FIG. 2. MOTOR BELTED FOR GROUP DRIVE

as such an arrangement would not carry a heavy one, but it gives satisfaction. The pulley *C* revolves in the direction opposite to that of pulley *A* without the use of a crossed belt, which always creates friction.

These two belts operate to good advantage, because the lower side carries the load as indicated by the arrow. Power is transmitted from the first countershaft to the pulley *D*, but this belt cannot work to the best possible advantage, because the upper side carries the load, leaving the lower side to fall away from the pulleys and reduce the arc of contact when it really ought to be increased. Fig. 3 shows a motor belted to a countershaft from which is belted a pipe-threading machine. A vertical belt always works at a disadvantage, because none of the weight of the belt rests on the lower pulley, hence all tractive power must be derived from a tight belt. If a tight belt is frequently shifted from one step of a cone pulley to another, it soon becomes loose and will not carry the given load. If the ceiling of the room is high, this adds to the difficulty of changing the belts.

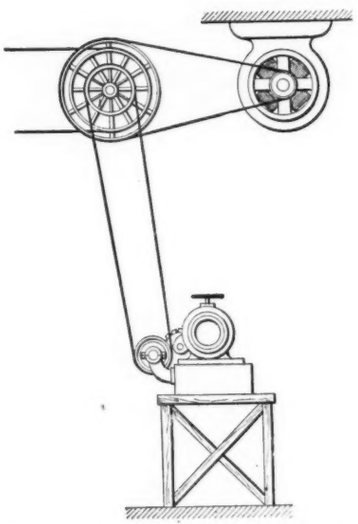


FIG. 3. VERTICAL BELT DRIVE

The lessons to be learned from the foregoing are that motors ought to be placed as the builders intended. Both motors and countershafts should be kept as low as possible. When possible, belts should be placed so that the lower side will carry the load and vertical belts avoided when conditions permit.

EDITORIALS

Wages and the Cost of Living

SOME enlightening figures upon the increased cost of living and the corresponding advance in wages in a number of industries, particularly the light and power group, are contained in the latest bulletin issued by the New York State Industrial Commission. The basis selected for comparison is June, 1914, a date representative of immediate pre-war conditions.

According to these statistics, the retail cost of foodstuffs has increased from that time to the present about seventy-five per cent., whereas the advance in wages in the light and power field during the same period has been sixty-eight per cent. This increase, while not nearly so great as that in certain other lines and trades, such as shipbuilding, the paper industry, etc., nevertheless compares favorably with that in the greater number of manufacturing plants, exclusive, of course, of those manufacturing war materials. Unfortunately, the figures do not discriminate between the classes of labor in the light and power industry, therefore it is impossible to form any deductions concerning the engineers and other operatives. Moreover, these figures represent averages only, and do not take into account injustices in certain individual cases, nor undue increases in others. However, making allowances for averages, it would appear that the increase in wages has not quite kept pace with the increase in cost of living, or at least in foodstuffs which may be taken as an index to the cost of living. While the difference is not so great as is generally supposed, it would appear that the average man in the light and power industry is economically somewhat worse off than he was five years ago. It is merely another example of the shrinking of the dollar.

While these figures are for New York State only, it may be assumed that they are fairly representative of the North Atlantic States, for, strange as it may seem, the figures for New York City did not differ materially from those of the entire state.

The Art of Synchronizing

THE many examples which could be cited of damage to apparatus and interruptions to service caused by carelessness in synchronizing or neglect in checking the synchronizing connections justify the injunction never to close the generator switch until the whole process has been checked up, by seeing the synchronoscope make one or more complete revolutions in a natural manner, and the synchronizing lamps checked against the synchronoscope to make certain that the latter is at the zero, or synchronizing, point when the lamps are dark. It is true that, except in the initial installation or during repairs or alterations, the likelihood of the synchronoscope connections becoming reversed is remote. This has happened, however, and the possibility always exists, particularly in plants where the operating force is large and work of some sort is continually being done on the switchboard apparatus. The man who considers himself capable in this line of work is due sooner or later to suffer a stern disillusionment unless he understands the principle of the entire synchronizing process and knows the layout and location of every circuit and every piece of apparatus. Operators of today have little excuse for poor synchronizing, considering the good regulation of the modern units, the positive action of the control apparatus and the stability of the load carried. They should consider the difficulties encountered by the operators of a few years ago, who had to synchronize many small, unstable units against a bus carrying a badly swinging load; when the coöperation between switchboard operator and engine room was scant, and the engineer could not always be persuaded to oblige by trying to hold the speed steady on the more or less ancient engine.

Much bad synchronizing is caused by operators not understanding their oil switches. Their principles and characteristics should be closely observed; for this purpose they should be frequently tried and inspected. The operator should know exactly the time lapse between the operating of the control switch and the closing of the oil switch. Motor-operated switches do this in less than one second; solenoid-operated switches in a slightly longer time. To the operator who is familiar with them, the indicating lamps tell the whole story of the remote-controlled oil switch's actions—the flicker of the lamp as the control is applied, the period when both lamps are lighted, then both dark, the positiveness of the second lamp's lighting—these things are indicative of the accuracy with which the switch is working.

An operator should be able to concentrate his mind so intently while synchronizing, that no distraction could lead him into making a false move. The habit of making false starts—nervously fingering the control switch, changing the mind when the switch is almost closed—betrays a lack of confidence and should be overcome. "Long chances" seldom pay, because usually some invisible factor is neglected. Quick thinking is good—when it is rational thinking. When the synchronoscope behaves queerly, taking a "pot shot" generally only makes an emergency situation worse, as pointed out in the article "Don't Take Chances With the Synchronoscope" on page 650 in this issue.

Increased Refrigerating Demands

THE exceptionally mild winter just past had its disadvantages as well as its advantages. It was welcome as a factor in keeping down the coal bill, but it is likely to contribute toward an increased bill the coming summer. The resulting scarcity of natural ice throughout a large section of the country will be felt by many communities and rural sections that have in the past depended in a large measure upon such supply. The result will be greatly increased demands for artificial ice, accompanied probably by an advance in price.

Aside from any price considerations, however, not only do the conditions point to increased demands for

refrigerating equipment for both new plants and extensions to old ones, but existing equipment will be taxed to the limit. Therefore it now behooves the engineer to practice a little preparedness in getting his machines in first-class condition for the grueling service of the summer season.

In doing so he will undoubtedly run across many conditions and adopt measures that will be helpful to brother engineers confronted with like problems.

This is essentially an age of coöperation, of collective effort, whether applied to nations, to industry, or to labor, and in no field is this more true than in that of the operating engineer, who usually has to meet and solve his problems single-handed. In this connection, then, he is urged to make greater use of the discussion pages of *Power* as a medium for such an exchange of ideas.

Put the Victory Loan Over!

FAILURE was the last thing to enter the minds of our soldiers who braved the horrors and privations of the war. Indeed, it is doubtful whether they even gave place to the thought. Their grim determination to carry on until the grueling task was finished drove out every unworthy doubt.

They refused to be dismayed, for their courage and honor were at stake. They did not underestimate the magnitude of the resistance they would have to overcome, but their pride would not suffer it to check them. They felt that they had a sacred duty to perform and they did it.

Therein lies a lesson for subscribers to the Victory Liberty Loan.

The absorption of the $4,500,000,000 of notes offered is a gigantic financial undertaking, but it is no larger than others that have been carried out successfully. The size of the loan should not daunt us, therefore.

Moreover, the full subscription of this amount is an obligation laid upon us, and it cannot honorably be evaded. Pride in our own steadfastness of purpose and integrity of action should keep each of us from attempting to shift his share of the burden to other shoulders.

Early reports indicate that the Victory Loan is being received enthusiastically and that many localities subscribed their entire quotas before the drive opened.

However, well begun is only half done. Let us finish the other half speedily!

Covering Data Marking

THE omission of little things frequently leads to considerable inconvenience, and this is especially true in power-plant practice. Take, for instance, steam-line valves. Considerable trouble and expense is taken to protect the steam-pipe lines against condensation. When the work is finished, it is attractive as well as economical, and as a general thing all goes well for a time.

Eventually, however, parts of the valve begin to give out, and in order to determine the number of any particular valve, it is necessary to tear away the covering of the valve body, on which the number is generally placed. This mutilation of the pipe-line insulation is of frequent occurrence, and it could easily be avoided if manufacturers would either stamp or have cast on the valve's bonnet all necessary distinguishing marks. If this were done, such valves would find immediate favor with engineers, provided, of course, all other points of design were equal to other makes of similar valves.

Take for another example, the feed-water heater. In all well-regulated plants it is covered with an insulating material. In most instances the nameplate and all other markings are covered. If the engineer desires to order new parts from the manufacturer for any particular size of heater, he has no means of determining its size or any other data that will give the maker definite information as to its exact design or size. This is particularly true where more than one type of heater is made by the same manufacturer.

Why would it not be well for manufacturers of all kinds of power-plant apparatus to place key numbers in such positions that they will always be exposed to view regardless as to whether the device is covered or not?

The engineer who leaves his engine room to attend to work on the outside should remember that if an accident occurs while he is absent, he and he alone will be held responsible, and if he is operating with a license the chances are that it will be taken from him. Let someone else do the outside work.

Almost every engineer will instruct his firemen to keep the surface of the steam boilers free from soot, but for all that there are a good many firemen who do not realize that their work would be made easier if they would follow such instructions.

The engineer who yearns to hold the manager's job because it involves nothing but wearing good clothes, smoking fat cigars and toying with a paper knife is an unconscious Bolshevist.

Setting engine valves with the aid of a knife blade as a gage may have been illuminating years ago, but the question arises, What is the standard thickness of a knife blade?

The perpetual-motion crank is the Bolshevist of the mechanical world, for he firmly believes that he can produce unlimited comforts and necessities without personal exertion.

When it comes down to a fine point the modern power plant, if it is to be efficient, will be on a daily, weekly and monthly test. If not there is room for improvement.

It is essential to have indicating and recording instruments in the boiler plant, but before they are of any benefit the fireman must be educated in their use.

Bare and poorly insulated steam and hot-water piping is one of the most easily preventable causes of steam-plant losses. Why allow the losses to continue?

How many engineers know how much heat goes up the chimney, and if so, how the amount could be reduced? It seems simple, but how about it?

Correspondence

How to Do a Good Job Cutting Conduit

It is well-known that conduit must not be cut with pipe cutters because of the sharp edge or burr that is left on the inside. Unless this burr is filed or reamed out, it will damage the insulation of the wires when they are pulled through the conduit. For this reason a hacksaw is used on most conduit jobs. However, the method is slow and it is also difficult to make a straight cut on the larger sizes of conduit.

A method that I have found very satisfactory is to use the pipe cutters first, cutting as deep as possible without causing the burr, then finishing with a hacksaw, which will not take long and will assure a straight cut.

It is surprising how this speeds up a conduit job. The value of this method increases with the size of the conduit.

L. W. WYSS.

Iron Mountain, Mich.

A Short-Circuit on Two Compound-Wound Generators

In his letter, "Generators Would Not Operate in Parallel," in the issue of Feb. 25, E. C. Parham describes a connection of two compound generators that will cause a short-circuit when they are connected in parallel.

In Fig. 1 of this article a connection is shown which is also unsatisfactory, but unlike that given by Mr. Parham, the equalizer connections are made correctly. The generator leads were run in conduit from the machines to the switchboard. When the machines were started for the first time, the following points were investigated and found correct: (1) Voltage across

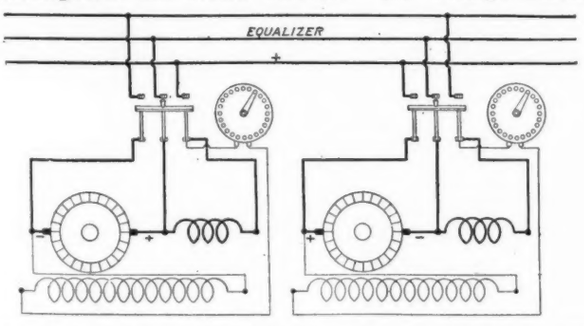


FIG. 1. WRONG CONNECTIONS FOR PARALLELING TWO COMPOUND GENERATORS

machine terminals were equal; (2) positive leads of machines to go to positive busbar and likewise negative leads to negative bus; (3) equalizer connection to equalizer bus and to the points on the generators where series field and armature are connected; (4) each machine was run separately under load and found to be overcompounded and the series-field shunts were adjusted for the correct value of compounding.

When the switches were closed to connect the machines in parallel, the circuit-breakers immediately opened. An examination of the connections shown in Fig. 1 will reveal that the armature of one generator is connected across the series field of the other, thereby causing a short-circuit.

It is evident that the four points mentioned will not fulfill all the necessary requirements. The fifth point is, armature terminals should go to the same busbar and likewise the series-field terminals, as in Fig. 2. When the machine leads run through conduit, care should be

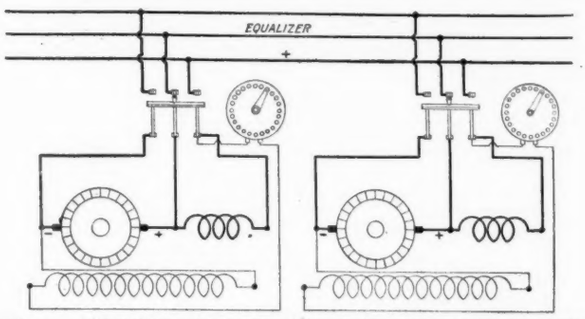


FIG. 2. CORRECT CONNECTIONS FOR PARALLELING TWO COMPOUND GENERATORS

taken in testing them so that when the connections are made the requirements in point five shall be fulfilled.

J. O. KAMMERMAN,

Associate Professor, Department of Electrical Engineering, University of Oklahoma.

Norman, Okla.

The Boiler Blowoff Cock Gives No Trouble

I have read considerable lately regarding boiler blowoff valves, and I would like to contribute a little of my experience. I have had 2-in. asbestos-packed blowoff cocks in use for six years without packing them and there are no signs of any leaks as yet; it is all in how they are handled. We carry 90 lb. pressure on the boilers, but we do not blow down at that pressure; that is done when the fires are banked, when the water is still in the boilers and when the pressure is low.

We blow into a tank that is quite a distance from the boiler. First the plug-cock is opened a little in order that the cold pipe leading from the blowoff valve to the tank will become gradually heated; then the cock is opened wide. In this way we get better results and the plug-cock will have the same wear all around. Always opening the cock halfway will in time cause a ridge to form along the plug and it will leak. We blow the boilers down every day.

I have never found it good policy to blow boilers down when under high pressure, as it is dangerous and fails to get the best results. Some blowoff valves are placed in restricted places, and if the blowoff pipe should give away while blowing down, the operator has no means of escaping injury.

PATRICK MOLLOY.

New York City.

Thermos-Bottle Principle Applied To Steam Cylinders

I notice in your Apr. 8 issue an article entitled "Thermos-Bottle Principle Applied to Steam Cylinders," from which it would appear that the University of Wisconsin some years ago made comparative tests with jacketed compound condensing engines with steam in the jackets and also with the jackets connected to condensers. The conclusion from these tests was that the vacuum in the jackets had not the slightest effect on the steam consumption.

The meaning of this is not perfectly clear. My experience has shown that the carrying of a vacuum in the jackets of a low-pressure cylinder effects a lower steam consumption than if this jacket were filled with air, but that the jacketing of the low-pressure cylinder with steam effects about the same economy as when vacuum is carried in the low-pressure jacket. It is, however, not sufficient to simply connect the jackets with the condenser, as then it will not be possible to extract the air out of them. The air can, however, be extracted if the jacket is connected with a small pipe directly to the air pump. To do this a small hole is drilled into the space between the suction and discharge valves of the air pump to which the jacket connection is attached with a small check valve opening toward the air pump.

In 1905 this question was tested out on an engine built by the Nordberg Manufacturing Co. for the Sperry Flour Mill Co. at its plant in Tacoma. This engine was of the tandem-compound type developing about 450 hp. It had a steam jacket on the high- and low-pressure cylinders, the jackets extending also over the cylinder heads. The engine was operated with 170 lb. pressure, and a very high degree of expansion was carried out. Oil was used as fuel, and the tests with this engine showed an oil consumption of 0.748 lb. of oil per indicated horsepower per hour. The fuel consumption was the same whether steam pressure or vacuum was carried in the low-pressure jackets, but increased if these jackets were allowed to fill with air. It seems as if the diminished internal condensation in the low-pressure cylinder is about offset by the radiation losses to the atmosphere from the heated cylinder walls when the low-pressure cylinder is jacketed with live steam. These radiation losses are eliminated when the jackets are under vacuum.

BRUNO V. NORDBERG,
President and Chief Engineer,
Milwaukee, Wis. Nordberg Manufacturing Co.

Keeping Explosion Doors Tight

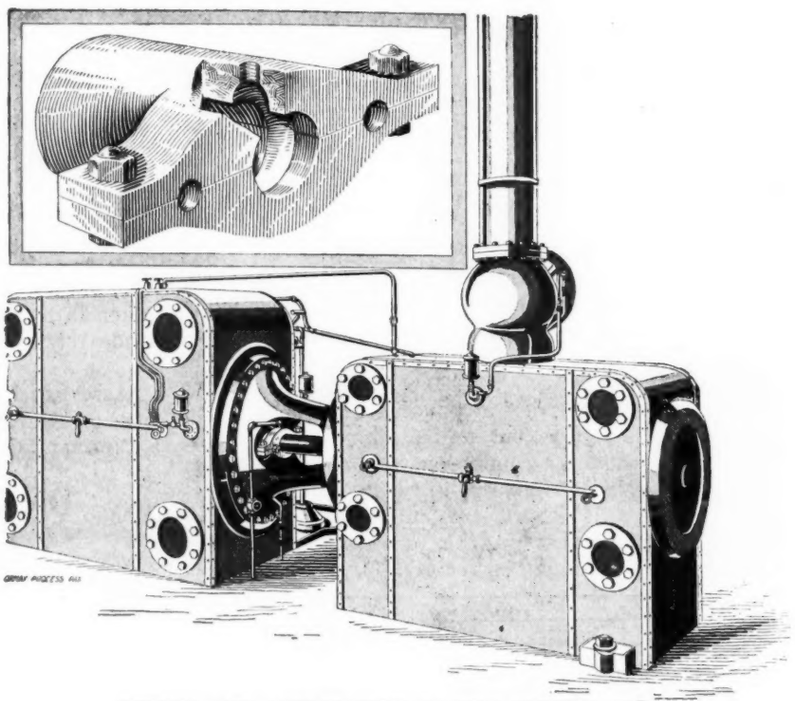
Explosion doors on boiler settings frequently give considerable trouble from air leaking in between the door and the frame. It is poor policy to go to the expense of applying a protective covering to the settings for the purpose of preventing the infiltration of air and then to allow the doors to pass large quantities directly into the furnace. After trying many ways of keeping these doors tight, I have at last found a very simple method which has solved the problem.

With doors hinged at the top, the frame extends from the wall several inches at the bottom, the door resting upon a packing ring laid into the frame, but it is difficult to keep this joint tight. I have seen many doors standing open at least one-half inch on the lower side. To remedy this I removed the $\frac{1}{2}$-in. pin from the hinge and replaced it with a $\frac{3}{8}$-in. one, which allowed the door to adjust itself to the packing ring. This is not possible when the door is held rigid by a tight-fitting hinge.

A. C. MCHUGH.
Norwalk, Calif.

Hunting Vacuum Troubles

On one unit it was formerly possible to get but 16 in. of vacuum, but it was not long until I was getting between 24 and 25 in. with the cooling water going to a cooling tower. The condenser was of the barometric type. We have been told to test for air leaks with a candle. Now, for large leaks a lighted candle works all right, but I find the following to be a good way of testing out: When the condensing apparatus is shut down, put the condenser under from 5 to 10 lb. of water pressure and the leak will be easily found. Some small leaks are hard to detect with a candle, especially outdoors where the wind blows the flame in all directions. On the relief valve I tried a candle and could not discover any leak, but when I used a light oil on it the leak was easily found and one could hear the noise made as the oil was pulled in.



DESIGN AND APPLICATION OF THE SPECIAL GLAND

I also run a tandem-compound engine that pulled in air around the low-pressure metallic piston packing, thus causing a drop in the vacuum. This was remedied by putting on a steam seal in the form of a special gland, as shown in the illustration.

Hartford, Conn. F. W. SCHNEIDER.

The Mobile Boiler Explosion

With reference to the boiler explosion at Mobile, Ala., described in the Mar. 25 issue, it might be of interest to know that we previously had trouble with the stay-bolts in the Heine boiler. In January, 1917, we found five of these stay-bolts broken. These were immediately replaced. The following November another was replaced and in October, 1918, two more. As the result of the large number of stay-bolts being broken we took the matter up with the insurance company, and their inspector advised us that he could see no reason for the breakage and the only recommendation which he could make was that the bolts be replaced at the time any were found broken.

On the night of the explosion and at the time of the accident, boilers Nos. 1, 2 and 7 in the new power house were in use, and in the old power house the Heine boiler was being fired and likewise No. 8 Stirling. Stirling boilers No. 5 and 6 had been cleaned and banked. In the new boiler room the stoker on No. 3 boiler had been pulled out for several days, having repairs made on it.

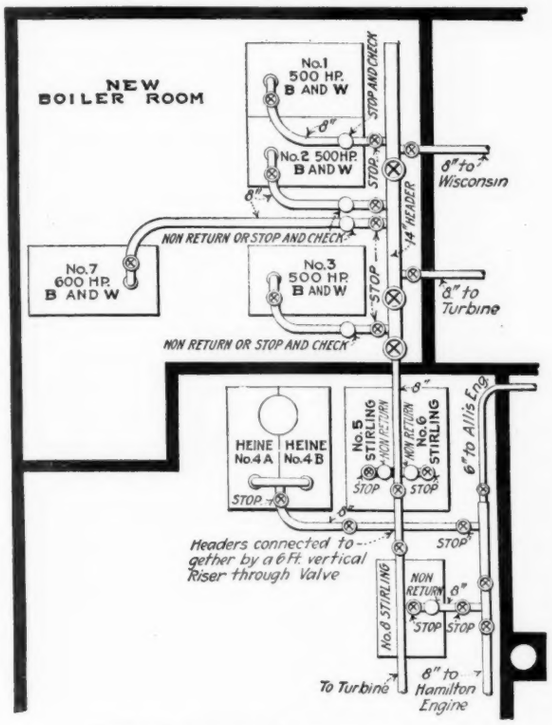
The chief fireman in the new boiler room stated that he was standing just in front of the alleyway between Nos. 2 and 3 boilers when he heard a cracking noise which he said sounded like the tearing of metal and at the same instant he saw the brick wall that divided the old boiler room from the new fall down. An instant later he was knocked down by flying bricks, and made his escape by crawling through a hole into the basement and thence through a basement window to the street. This statement, together with the trouble which we had experienced with the stay-bolt, indicates to me that it was the Heine boiler which exploded first. Examination of this boiler after the explosion showed that the rear water-leg broke along the top row of tubes, and a portion of this rear water-leg was found fastened to the rear drum and was bent very much out of shape so as to be in a position that would indicate that the water-leg was forced backward and very nearly horizontal. This water-leg gave way with such violence that it went through the 18-in. wall between the boiler room and hit a building column that supports both the east front of the boiler and a portion of the overhead coal bunkers. The force was so great that this column, which is made up of channels and boiler plate riveted, was bowed at a point half way between the floor and the top of the setting of boiler No. 3 so as to be very nearly twelve inches out of line. The buck-stay on the same side of the boiler was also bent about the same amount. The whole east brick wall of the boiler setting was forced in, with the result that all the brickwork on the boiler had to be torn down and the boiler had to be entirely rebricked. The insurance company thought it advisable that the boiler also be retubed; which was done. This boiler was set singly, and the west column supporting it was also bowed to nearly the same extent as the east one. The chain-grate stoker which had been rolled out was hit with such violence that all the frame castings, such as side girders and side frames, had to be replaced.

Inasmuch as an indentation in the head of No. 6 Stirling was found after the explosion and as the head itself was found practically at the same point where the mud drum of this boiler landed, it would seem that this head was knocked out and not blown out.

On the night of the accident there were thirteen men in the power house. The first assistant engineer, William Detlefsen, who has been an employee of the company for about eighteen years, was in the lavatory, and his statement was to the effect that he felt a mighty tremor. Immediately the lights went out and he was knocked down. He regained his footing and attempted to open the door, but was again violently knocked down and finally escaped through a window.

James Hudson, a switchboard operator, was standing near a division wall between the old and the new engine room. He stated that he heard no violent explosion and was quite unaware that anything had taken place until he realized that he had been knocked down and was unable to move. He was buried in the bricks from the fallen wall and sustained severe burns from hot water and steam.

Two oilers were in conversation at the cylinder end of the 1000-kw. Wisconsin engine. Both were knocked



BOILER PIPING AT MOBILE PLANT

down, one being severely injured by flying bricks, whereas the other was absolutely unhurt.

In the new boiler room there were three men. The head fireman made his escape as already stated. Another man had his legs broken in three different places and received burns, and died within a few days at the hospital. The third man was so severely scalded that he died within a few hours after the accident. The man firing the Heine and the man firing No. 8 Stirling boiler in the old boiler room were both killed outright. Two firemen who had come off of duty at 8 p.m. were upstairs changing their clothes. These men were severely scalded and also died within a few days. In the basement were two ash pullers. One was unhurt, whereas the other received a few burns.

Attached is a sketch showing roughly the steam piping and location of the valves.

A. D. QUACKENBUSH,
General Superintendent, Mobile Electric Co.
Mobile, Ala.

Revision of Technical Courses

In your editorial of Feb. 25, in regard to revision of technical courses, you have touched on a timely subject, but I do not believe that you have covered every phase of the subject. It does not seem to me that more time should be put on this very important department of studies, but that the work should be given the engineer in a sympathetic manner and in such a way as will enable him to use mathematics as a tool in his subsequent work.

For a long time mathematics (one of the three fundamental engineering subjects) was given in the Science College of the University of Washington. For these professors mathematics is a most serious subject. In fact it is the only subject, and they think that the student must love it for its own self. Problems of the most academic sort become for the mathematics teacher a source of joy and delight. The following story is apropos: A mathematics teacher wrote a long differential equation on the board (two miles above the students' heads, figuratively speaking), stood back looking at it and said, "Isn't it pretty?"

We in the progressive engineering school of today now stand for mathematics to be so given as to enable the student to use it as a tool. He should have as complete and thorough training as it is possible to obtain in the high school, but in the college the subject must be given with the viewpoint that it must be usable and that the student should understand what he is doing and how he may make use of it. It is not usually understood that in the regular four-year engineering course, 2½ years are used in preparation for the professional work and the remaining 1½ years on subjects for which the student elected to enter college. The preliminary work is necessary, but it must be given in a sympathetic manner. One should remember that the engineering student is preparing himself for a certain kind of work in his future life. He has selected a certain branch of engineering. Therefore if the connection between the preliminary work and the later work is kept clear at all times, better results will be obtained.

As regards a review course in mathematics in the senior year, I believe this unnecessary. Applied mechanics, hydraulics, thermodynamics, machine design and numerous other professional subjects are the review of mathematics which engineers need, and this is what they get, and they see the bread-and-butter application of mathematics always before them. Therefore I stand for better presentation of mathematics; a method which will allow the engineer to apply the subject to his everyday problems. H. J. MACINTIRE.

Seattle, Wash.

The Cost of Banking Fires

After reading your editorial on the "Cost of Banking Fires" and seeing but one reply so far, I will describe the method I use in the plant of which I am in charge.

The manner of banking fires depends largely on the kind of coal, the time the fires are banked and the quickness with which the banks must be knocked down and the fires gotten under way. Some coals ignite easily and require only the hot furnace to ignite them, but with others a certain amount of fire must be left upon which to throw the green coal. Sometimes the bank has to be covered with ashes to keep the coal from burning out and running up the pressure, which is undesirable The plant under consideration consists of 72-in. x 16-ft. return-tubular boilers with 6 x 6-ft. hand-fired grates, both shaking and stationary. The fires are banked an average of twelve hours each day of the year.

Contrary to usual practice I have the fires banked on the front of the grates. The live coal is pushed well back to the bridge-wall and all ash raked out. The live coal is then pulled to the front and green coal is piled upon the live coals, completely covering them in some cases and only partly so at other times, depending on the coal. The bank can be placed well up on the dead-plate or more on the grate, depending on the kind of coal. This gives a certain amount of control of the bank, so that the pressure will not run up and cause the safety valve to blow; at the same time the bank can be allowed to burn well through.

When it is time to get the fires going, it is only necessary to spread the bank and put on the draft, and in a few minutes the fire is good and hot, ready to make steam enough to pick up quite a load. And this ability to get under way quickly is important where boilers are banked in readiness to supply steam to fire pumps in case of a fire alarm or when considerable load must be picked up quickly. Some bank the fires just as they are when shutting the boilers down, by covering the fire with green coal and then cleaning when starting up, but I do not like that method.

The quantity of coal required to bank a fire under each boiler as I have described runs from 90 to 125 lb. As a rule 90 lb. is sufficient. Plants requiring as much as one-third of the total coal consumption for banking must operate but a small part of the time or else the fires must be kept burning slightly in order to supply leaks and thus hold up the pressure.

To obtain the best results from banked fires and keep stand-by losses down, it is necessary that steam leaks through valves and traps, also hot-water leaks, be kept as low as possible.

Where the steam lines are kept hot, nothing should be lost from the boilers but the condensation, and sometimes it is advisable to cut the boilers out entirely. It is surprising how much water a boiler will lose on account of a few steam leaks even when the fires are banked. CLIFFORD F. DANNER.

Lacombe, Alta., Canada.

Approximate Capacity of Pump

In the Feb. 4 issue of *Power*, page 183, is a formula for the approximate capacity of a pump, which is as follows:

$$g = \frac{D^2 \times 0.7854 \times L \times N}{231}$$

where

g = Gallons pumped per minute;
D = Diameter of plunger or piston in inches;
L = Length of stoker in inches;
N = Number of single strokes per minute.

This is then simplified to read

$$g = \frac{D^2 \times L \times N}{294.117}, \text{ usually written, } \frac{D^2LN}{294}$$

This can be simplified still further, making it easier to handle and as well to remember: $g = D^2LN\ 0.0034$.

Lakewood N. J. L. A. KEWOOD.

Inquiries of General Interest

Electrical Generator Running in a Vacuum—Would an electric generator operate if it were placed in a vacuum? J. V. M.

Yes, as far as generating a voltage is concerned, and the windage losses would be practically zero. However, there being no means of ventilating the machine and a vacuum being practically a nonconductor of heat, it is doubtful if the machine could supply the power to excite its own field coils without overheating except for a very short period. If the field coils were separately excited, they would soon overheat for the reason mentioned.

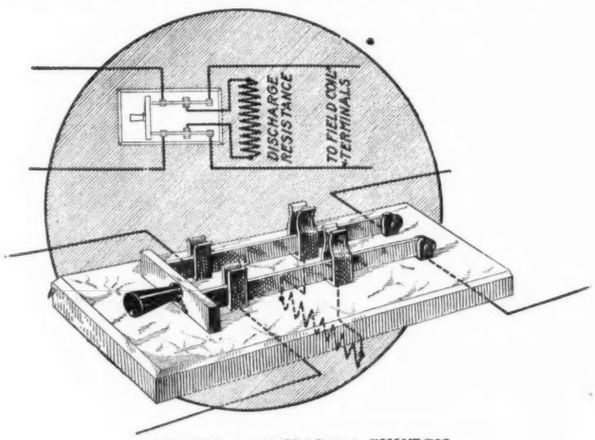
Standard Temperatures of Melting Points—What are the temperatures of the melting points of various substances that may be used as standards? W. N. A.

The melting points used by the Bureau of Standards as standard temperatures for the calibration of thermometers and pyrometers are as follows, expressed in degrees Fahrenheit:

Mercury	37.97	Antimony	1,166	Nickel	2,646
Tin	449.4	Aluminum	1,217.7	Iron	2,786
Cadmium	609.6	Silver	1,760.9	Palladium	2,820
Lead	621.3	Gold	1,945.5	Platinum	3,191
Zinc	786.9	Copper	1,981.4	Tungsten	6,152

Field Discharge Resistance—We have a 100-kv.-a. alternator and wish to build a field discharge resistance for it. How is the ohmic value of the resistance determined? M. P.

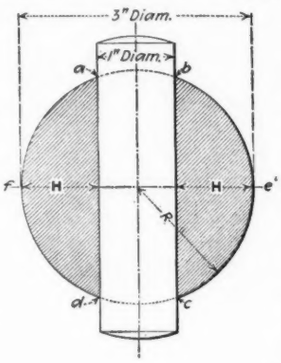
The general practice for alternators is to make the ohmic value of the discharge resistance equal to the normal voltage of the exciter divided by three times the minimum field current, that is, the current flowing in the field windings, when all the rheostat resistance is cut into circuit. As an example assume the exciter's voltage to be 125 and when the rheostat is all cut into the alternator's field circuit it takes 5 amperes; then the ohmic value of the discharge resistance is $\frac{125}{3 \times 5} = 8\frac{1}{3}$ ohms. This resistance is usually made so as to carry the field current for thirty seconds without overheating. The circuits should be connected to a switch so designed that the field windings cannot be disconnected from the exciting circuit before it is connected to the discharge resistance as indicated in the figure.



FIELD DISCHARGE SWITCH

For a synchronous motor the discharge resistance is calculated the same as for an alternator, but the resistance is made so as to carry the field current for two minutes. For a direct-current generator the ohmic resistance of the field discharge resistance is made equal to the normal voltage of the machine divided by the field current in amperes when all the rheostat resistance is in circuit; in other words, divided by the minimum field current at normal voltage.

Reduction in Tensile Strength of Piston Rod—What percentage of tensile strength of a piston rod is lost by drilling a 1-in. diameter pinhole through the center of the rod where it is 3 in. in diameter? M. J.



Referring to the figure, the 1-in. diameter pinhole *abcd* drilled through a 3-in. diameter piston rod whose original cross-sectional area was equal to the area of circle *abecdf* would leave a total cross-sectional area of rod equal to the sum of areas of the equal segments *bec* and *dfa*. As 1 in + $2H$ = 3 in., then H, the height of each circular segment, would be equal to 1 in. The area of a circular segment is given by the formula,

$$Area = \frac{4H^2}{3}\sqrt{\frac{2R}{H} - 0.608}$$

in which H is the height of segment and R the radius of the circles. As $H = 1$ in. and $R = 1\frac{1}{2}$ in., by substituting, the area of *bec* or *bfa* is found to be $\frac{4 \times 1}{3}\sqrt{\frac{2 \times 1\frac{1}{2}}{1}} - 0.608$ = 2.06 sq.in., or for both segments, 2.06 × 2 = 4.12 sq.in. As the original cross-section of the rod due to 3-in. diameter was 3 × 3 × 0.7854 = 7.07 sq.in. and as drilling the hole would remove 7.07 − 4.12 = 2.95 sq.in. of cross-sectional area, the loss of tensile strength would be 2.95 × 100 ÷ 7.07 = 42 per cent.

Thickness of Plates for Boiler Shell—What should be the thickness of steel plates of 55,000 lb. TS for a boiler shell 6 ft. 6 in. diameter to carry a working pressure of 125 lb. per sq.in. with a factor of safety of 5, if the longitudinal seams are triple-riveted butt-and-strap joints of 84 per cent. efficiency? F. J. L.

The stress on one inch of length of the longitudinal joint of a cylindrical shell is equal to one-half of the product obtained by multiplying together the working pressure per square inch, the diameter and the factor of safety, or where P = working pressure, in pounds per sq.in., R = radius in inches, and FS = factor of safety, the required stress of 1 in. length of longitudinal joint = $\frac{1}{2} \times P \times 2R \times FS = P \times R \times FS$.

The resistance of 1 in. length of the longitudinal joint would be equal to the product obtained by multiplying together the ultimate tensile strength of the material, the thickness of plate and the efficiency of the joint, or where TS = ultimate tensile strength of plate in pounds per square inch of cross-section, t = thickness of plate in inches, and E = efficiency of the joint, the resistance of 1 in. length of joint = $TS \times t \times E$.

As the resistance must equal the stress,

$$TS \times t \times E = P \times R \times FS, \text{ or } t = \frac{P \times R \times FS}{TS \times E}$$

Calling TS = 55,000 lb., E = 0.84, P = 125 lb. per sq.in., $R = \frac{1}{2}$ of 6 ft. 6 in. = 39 in., FS = 5, then, by substitution, the last equation becomes

$$t = \frac{125 \times 39 \times 5}{55{,}000 \times 0.84} = 0.5276, \text{ or about } \frac{33}{64} \text{ inch.}$$

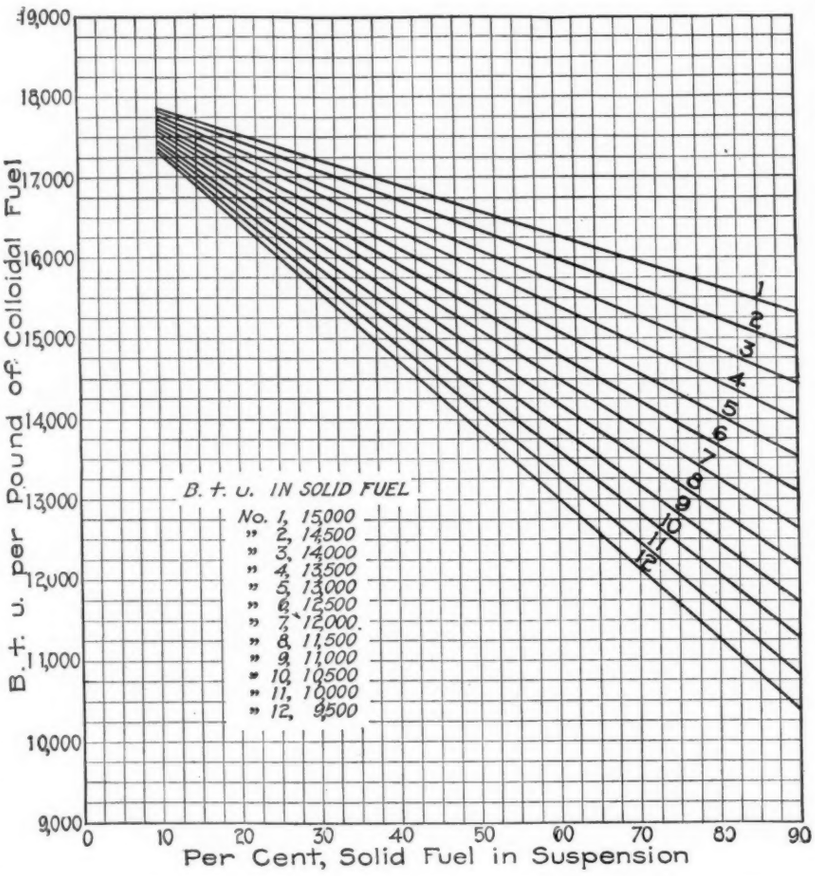
Tests of Colloidal Fuel

IN THE MAY 28, 1918, issue brief reference was made to tests that were being conducted of colloidal fuel at New Haven by the Submarine Defense Association with a view to conserving the fuel-oil supply of the Navy. It is now possible to give further detailed information concerning these tests, which have been worked up under the direction of Lindon W. Bates, secretary of the association.

The trials were conducted on the patrol boat "Gem," a converted yacht with two 265-hp. oil-burning boilers of the Normand Express type, and extended over a period of several months.

The idea of an oil-coal combination is not new, but the difficulty heretofore has been due largely to the settling out of the heavier coal or tar product. In the present tests highly satisfactory results appear to have been obtained with a mixture consisting approximately of 69 per cent. fuel oil, 30 per cent. pulverized coal and 1 per cent. of a fixateur whose function is the stabilizing of the separate elements of different specific gravities so as to maintain a homogeneous product. Other mixtures also gave fairly good results.

The coal used in the tests averaged about 13,900 B.t.u. per lb., with an ash content of 11.4 per cent. Before mixing, it was ground so as to pass through a screen of 300-mesh, or 90,000 holes per square inch. Very little change was made in the oil storage tanks, the piping, preheating or burning mechanism, except that five instead of seven mechanical burners were used. At approximately 150 deg. F. and 150 lb. oil pressure the atomization of the colloidal fuel was as good as that of the fuel oil alone, and the B.t.u. consumption per indicated horsepower was about equal to that of the regular fuel oil. The heat value of the colloidal fuel, per unit of weight, due to the lower heat value of the coal, was somewhat less than that of the fuel oil alone—in the ratio of about 17,000 to 18,000; but owing to its greater specific gravity the heat value per unit of volume was slightly greater. Therefore, although the saving of oil for equal weight was 31.2 per cent., due to the lower heat value per pound of colloidal fuel compared to oil, about 10 per cent. more of the former by weight is needed to produce equal results. This means a net saving for equal volumes of about 27 per cent.



COLLOIDAL FUEL COMPARED WITH COAL OF VARIOUS PRICES

Table I shows comparative costs of oil fuel and colloidal fuel with coal at various prices. This, presumably, is exclusive of the cost of pulverizing the coal. The curves show the heat value of colloidal fuel with varying percentages of solid fuel in suspension with oil of 18,200 B.t.u. per pound.

Further tests indicated that it is possible to produce a stable liquid fuel from about 45 per cent. oil, 20 per cent. tar and 30 per cent. pulverized coal, together with a fixateur, thereby replacing over one-half of the oil. Also, by the greater use of higher sulphur oils or coals, the sulphur content of the mixed fuel can be reduced. The latest test with a mixture consisting of 30 per cent. Pocahontas coal, 8½ per cent. Texas Navy oil, 28.8 per cent. Mexican topped oil, 31.2 per cent. pressure still oil and 1½ per cent. fixateur, gave the following results as compared with those obtained on the same boiler with straight Mexican topped oil:

TABLE I. COMPARATIVE COST OF OIL FUEL AND COLLOIDAL FUEL WITH COAL AT VARIOUS PRICES

Specific gravity of oil = 0.960
Specific gravity of coal = 1.40

Price of Straight Oil per Gal.	Price of Straight Oil per Bbl.	Cost of Colloidal Fuel — Coal at	Coal at	Coal at	Coal at	Coal at
		$1.00	$2.00	$3.00	$4.00	$5.00
1c.	$0.42	$0.65	$0.74	$0.82	$0.91	$0.99
2	.84	.92	1.01	1.10	1.18	1.27
3	1.26	1.20	1.28	1.37	1.45	1.54
4	1.68	1.47	1.56	1.64	1.73	1.81
5	2.10	1.74	1.83	1.91	2.00	2.09
6	2.52	2.02	2.10	2.18	2.27	2.36
7	2.94	2.29	2.38	2.46	2.54	2.63
8	3.36	2.56	2.65	2.74	2.82	2.91
9	3.78	2.84	2.92	3.01	3.09	3.18
10	4.20	3.11	3.20	3.28	3.36	3.45
11	4.62	3.38	3.47	3.55	3.64	3.72
12	5.04	3.65	3.74	3.83	3.91	4.00

TABLE II. COMPARATIVE TESTS OF COLLOIDAL FUEL GRADE No. 13 AND MEXICAN OIL

	Colloidal No. 13	Mexican
Test No.	6	1
Date	3/24/19	3/7/19
Length of test, hours	8	8
Quality of steam, per cent	97.2	97.3
Equivalent evaporation per hour	17,486	16,200
Fuel as fired, lb. per hour	1,286	1,159.5
Actual evaporation per pound fuel	11.6	12.06
Equivalent evaporation per pound fuel	13.6	13.97
Boiler horsepower developed	507	481.98
Per cent. rated capacity	126	119.6
B.t.u.	17,200	18,482
Efficiency, per cent	76.8	7332

For several months the British admiralty has been at work raising vessels that were sunk by German submarines. So far, over four hundred merchant ships have been salvaged, although most of them had heretofore been counted a dead loss. Since the U-boats preferred to lie in wait for their victims near the coast, a large proportion of the sinkings took place in comparatively shallow water, which makes the salvaging much easier. The ship is raised by patching the hole in its side, which is done by divers, and then pumping out the hold. Work is done by huge submersible pumps lowered into the hold of the ship.

Crude Petroleum in the United States

The following comparative preliminary estimate by the United States Geological Survey, of the quantity of crude petroleum produced and marketed, consumed and held in storage in the United States in February and January, 1919, and February, 1918, is based on reports filed by about two hundred pipe-line, marketing and refining companies that receive crude oil directly from the productive fields east of the Rocky Mountains and upon statistics for California compiled from secondary sources because first-hand data could not be procured without undue delay. This statement, which does not take account of imports, indicates the general trend of conditions in the domestic crude-petroleum industry.

The quantity of crude petroleum run from wells and producers' field-storage tanks and delivered to pipe lines, marketing companies and consumers in the United States in February, 1919, amounted to approximately 26,511,000 bbl., a decrease of 3,358,000 bbl., or 13 per cent., compared with January, 1919, but an increase of 758,000 bbl., or about 3 per cent., compared with February, 1918. The average daily rate in February, 1919, was 946,822 bbl., a quantity less by 16,695 bbl., or nearly 2 per cent., than the average daily rate in the preceding month, though greater by 27,072 bbl., or 3 per cent., than that in the corresponding month of last year. As there are 31 days in January and only 28 in February, 1919, the monthly rates of production indicate a relative decline in the production of crude oil in February, 1919, compared with January, 1919, that is more apparent than real. The average daily rates of production, however, which in a comparison of this kind give an accurate index to the relative changes in movement of crude oil from the productive sources, show a decrease in February, 1919, compared with January, 1919, of only about 2 per cent., a condition due to the failure of the flush production in Central and North Texas to offset the decrease in the Cushing pool, Oklahoma, and in the Illinois field, which has been steadily declining in oil production for many years.

It is estimated that 27,159,000 bbl. of domestic crude petroleum was delivered in February, 1919, to refineries

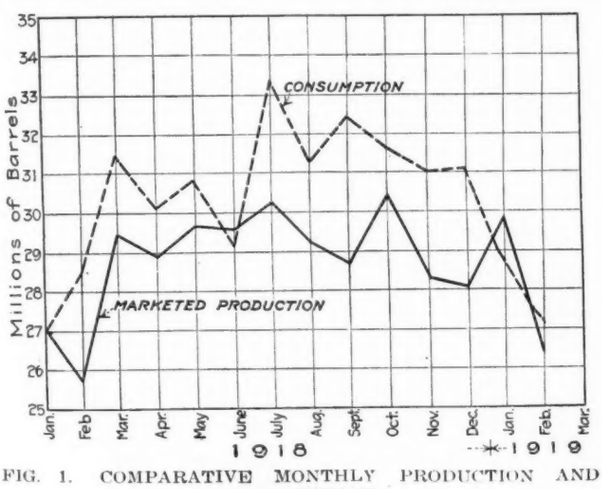
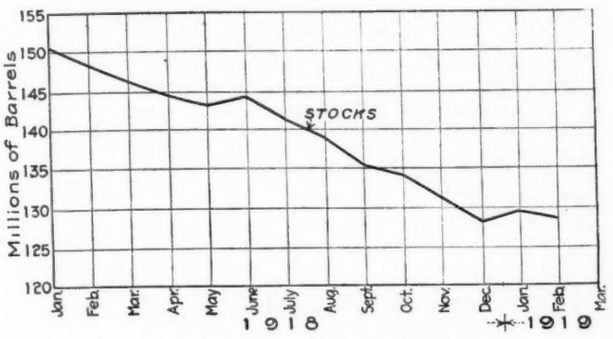


FIG. 1. COMPARATIVE MONTHLY PRODUCTION AND CONSUMPTION

and other consumers of crude oil and used for the manufacture of petroleum products and for fuel. This quantity is less by 1,463,000 bbl., or about 5 per cent., than the quantity so delivered and consumed in January, 1919, and by 1,143,000 bbl., or only 4 per cent., less than the consumption in February, 1918. However, the average daily rate of consumption in February, 1919, which is more significant than the monthly rate, was 969,966 bbl., an increase of 46,676 bbl., or nearly 5 per cent., compared with the daily rate in January, 1919, though a decrease of 40,820 bbl., or 4 per cent., compared with the rate in February, 1918.

The surface reserve of crude petroleum held on Feb. 28, 1919, by pipe-line and marketing companies and refineries that receive it directly from the wells was approximately 128,910,000 bbl., a decrease of 648,000 bbl., or 5 per cent., compared with the quantity on hand Jan. 31, 1919, and a decrease of 19,219,000 bbl., or 15 per cent., compared with the quantity in storage on Feb. 28, 1918.

Approximately 95 per cent. of the crude oil above ground in the United States in the months specified is included



MONTHLY STOCKS, 1918-1919

in the table, the remaining 5 per cent. representing unmarketed oil run by producers to private tanks and held as field storage.

STOCKS OF CRUDE PETROLEUM AT END OF MONTH
(Barrels of 42 gal. each)

Class of Oil	February, 1919	January, 1919	Increase or Decrease, Feb.-Jan., 1919	February, 1918	Increase or Decrease, Feb., 19 Feb., 1918
Appalachian....	3,969,000	3,777,000	+ 192,000	3,924,000	+ 45,000
Lima-Indiana..	1,229,000	1,181,000	+ 48,000	1,610,000	— 381,000
Illinois*.....	3,026,000	2,504,000	+ 522,000	3,331,000	— 305,000
Mid-Continent.....	78,107,000	80,252,000	—2,145,000	97,878,000	—19,771,000
Gulf Coast.....	8,866,000	8,528,000	+ 338,000	9,522,000	— 656,000
Rocky Mountain.....	1,042,000	1,016,000	+ 26,000	513,000	+ 529,000
California†....	32,671,000	32,300,000	+ 371,000	31,351,000	+ 1,320,000
Total.....	128,910,000	129,558,000	— 648,000	148,129,000	—19,219,000

* Includes Lima-Indiana oil stored in Illinois by the Illinois Pipe Line Co.
† Includes field, pipe line and refinery stocks of crude oil, residuum and unfinished refinery products.

The Making and the Destruction of Steel

Another overflow crowd attended a joint meeting of the mechanical engineering section of the Western Society of Engineers and the Chicago section of the American Society of Mechanical Engineers, held in the rooms of the former society on Apr. 21. Robert J. Young, manager of the Department of Safety and Relief, Illinois Steel Co., showed some interesting reels illustrating the triplex process of making steel. As an introduction the first reel showed mining methods in Minnesota, where three-fifths of the iron ore is obtained, loading boats at the dock and unloading at the mills. Subsequent pictures followed the process through the blast furnace, the bessemer converter and the openhearth furnace and the refinement of the metal in the electric furnace, of which the company recently installed three of 25 tons capacity. The series of reels presented were exceptionally good for steel-mill pictures and were highly appreciated by the audience.

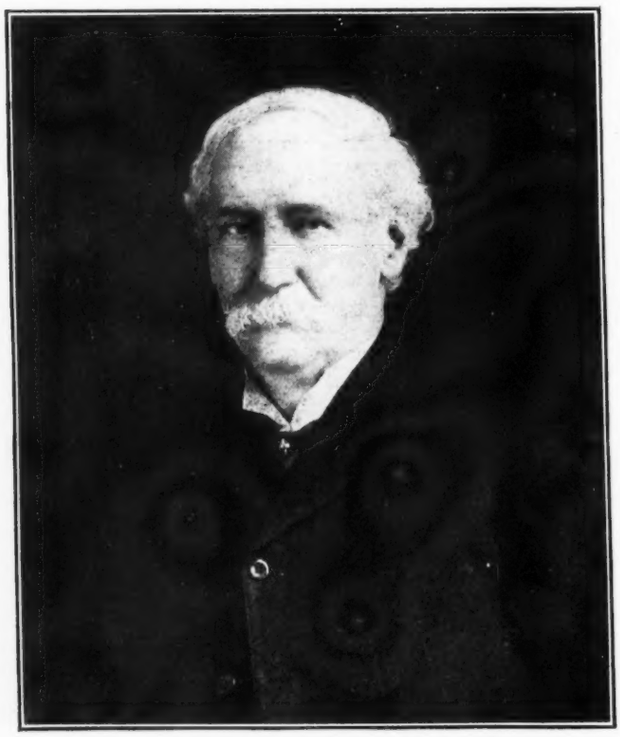
Prof. Herbert F. Moore, Department of Experimental Engineering, University of Illinois, talked on the "Fatigue of Metal." By means of successive photomicrographs of metals under stress the speaker showed the development of a fracture due to repeated loading. Numerous fine cracks first appeared and spread on the surface of the metal, and eventually at the point of greatest stress one or a series of these surface cracks developed into the fracture. The old theory of crystallization could no longer be accepted and failure from fatigue due to repeated stresses below the elastic limit was quite possible, notwithstanding the usual conception to the contrary. Also the impact test was not reliable. On numerous occasions it had been demonstrated that a polished surface added to the strength of the metal, as the fine surface cracks did not develop so readily.

Prof. Charles B. Richards

Charles B. Richards, Emeritus Professor of Mechanical Engineering at Yale, died at his residence, 227 Edwards St., New Haven, Conn., on Apr. 20, in his 86th year.

Professor Richards was born in Brooklyn, N. Y., Dec. 23, 1833, and was educated in private schools in that city. In his early days he moved to Hartford, Conn., and upon his removal from there to New York, came in contact with the late Charles T. Porter, by whom he was employed to assist in the preparation of drawings for a machine for drilling the arms and balls for his governor.

He later established himself as a designer of machinery and in 1861 was commissioned by Mr. Porter to design a steam-engine indicator that would overcome the faults of the instruments then in use, which were only for use on engines of slow speed. After repeated attempts, young Richards became discouraged, but goaded by Porter's insistence that he must have a high-speed indicator, renewed his efforts and the celebrated Richards Indicator was the result. When asked to patent the indicator, Richards refused, saying: "If I patent everything I think of, I shall



CHARLES B. RICHARDS

soon be in the poorhouse." He finally agreed to sell his right in the invention to Porter for one hundred dollars, Porter to patent it and to employ him to obtain the patent. For the achievement of inventing the indicator he was made a Chevalier of the Legion of Honor of France.

Fon many years he was consulting engineer and assistant superintendent of Colt's Patent Fire Arms Co., Hartford, Conn., and while there designed and superintended the building of the two pairs of Porter-Allen engines which are still furnishing power to the older part of that establishment. The beds for these engines were cast in the foundry of one of the old engine builders in Hartford, who called on General Franklin, the general manager of Colt's Armory, to warn him that if Richards was permitted to put these engines in the second story of the building and run them at 100 r.p.m., disaster would be certain. The engines were started in 1867 and have been running almost continuously since that time.

Professor Richards was superintendent of the Southwark Foundry and Machine Co., Philadelphia, Penn., from 1880 to 1884, and was called from there to take the chair of mechanical engineering at Yale. He served as professor in that branch until 1909, since which time he has been professor emeritus.

He was United States Commissioner to the Paris Exposition of 1889 and has been consulting engineer for many public buildings, notably the State Capitol at Hartford. He was a member of the Société Industrielle de Mulhouse, a fellow of the American Academy of Arts and Sciences and a member of the American Society of Mechanical Engineers, being present at the meeting for organizing the last-named society on Apr. 7, 1880.

Professor Richards was married in 1858 to Miss Agnes Edwards Goodwin, of Hartford, Conn., who with four daughters and one son survives him.

Principles of Combustion in the Steam Boiler Furnace

"Principles of Combustion in the Steam Boiler Furnace" is the title of a new work by Arthur D. Pratt, of the Babcock & Wilcox Co., which publishes the book. As assistant to Dr. D. S. Jacobus, that company's advisory engineer, Mr. Pratt devotes much of his time to combustion and heat-transmission problems. The book, therefore, embodies much of the company's practice.

Instead of the usual review it is believed that readers of *Power* would like a more comprehensive "view" of this excellent book. It is in thirteen sections, dealing with the chemistry of combustion, density, weight and volume of gases, heat of combustion, specific heat, temperatures developed in combustion, air and combustion, combustion formulas, combustion loss, smoke, general conclusions.

Section XII deals with the computation of combustion data relative to coal, wood, oil, natural gas, byproduct coke-oven gas and blast-furnace gas. Section XIII treats of the heat balance for solid, liquid and gaseous fuels. These two sections are particularly valuable.

The following table is from page 10.

TABLE I. ELEMENTS AND COMPOUNDS ENCOUNTERED IN COMBUSTION

Substance	Molecular Symbol	Atomic Weight Accurate	Atomic Weight Approx.	Molecular Weight Accurate	Molecular Weight Approx.
Carbon	C*	12.005	12	†	...
Hydrogen	H_2	1.008	1	2.015	2
Oxygen	O_2	16.00	16	32.00	32
Sulphur	S_2	32.07	32	64.14	64
Nitrogen ‡	N_2	14.01	14	28.02	28
Carbon monoxide	CO	.....	.....	28.01	28
Carbon dioxide	CO_2	.....	.....	44.01	44
Methane	CH_4	.....	.....	16.03	16
Acetylene	C_2H_2	.....	.....	26.03	26
Ethylene	C_2H_4	.....	.....	28.03	28
Ethane	C_2H_6	.....	.....	30.05	30
Sulphur dioxide	SO_2	.....	.....	64.07	64
Hydrogen sulphide	H_2S	.....	.....	34.08	34
Water vapor	H_2O	.....	.....	18.02	18
Air	.....	.....	.....	28.94	29

* Atomic symbol. † The molecular weight of C has not been definitely determined. Carbon exists in a number of forms, each of which probably has its own molecular weight. The latest investigations indicate that a molecule of carbon in any form consists of at least 12 atoms. ‡ Atmospheric nitrogen as distinguished from chemically pure nitrogen, which has an atomic weight of less than 14.01.

Table II is from page 18, and designated Table 5.

TABLE II. DENSITY, WEIGHT AND VOLUME OF GASES AT ATMOSPHERIC PRESSURE AND 32 DEG. F.

Substance	Molecular Symbol	Relative Density Air = 1	Relative Density Hydrogen = 1*	Weight per Cu.Ft. Lb.	Cu.Ft. per Lb	Value of Constant R in $PV = RT$
Air	.....	1.0000	....	0.08071	12.390	53.33
Oxygen	O_2	1.1053	16	0.08921	11.209	48.24
Hydrogen	H_2	0.0696	1	0.0562	177.936	765.8
Nitrogen	N_2	0.9673	14	0.07807	12.809	55.13
Carbon monoxide	CO	0.9672	14	0.07806	12.811	55.15
Carbon dioxide	CO_2	1.5291	22	0.12341	8.103	34.88
Methane	CH_4	0.5576	8	0.04500	22.222	95.64
Acetylene	C_2H_2	0.9200	13	0.7425	13.468	57.97
Ethylene	C_2H_4	0.9674	14	0.7808	12.807	55.12
Ethane	C_2H_6	1.0494	15	0.8470	11.806	50.81
Sulphur dioxide	SO_2	2.2639	32	0.18272	5.473	23.56
Carbon†‡	S_2	.....	....	145	0.0069	.....
Sulphur	.....	.....	....	125	0.0080	.....

* Based on approximate molecular weights. † Solid. ‡ If carbon can be conceived to exist as a gas, under standard conditions its relative density would be 0.820; its weight per cubic foot 0.0668 lb., and its volume 14.97 cu.ft. per pound.

Experiment shows that if the temperature of a perfect gas at 32 deg. F. is increased one degree, the pressure being kept constant, the gas expands $\frac{1}{491.64}$ part of its

volume. If such a rate of expansion per degree increase in temperature held good at all temperatures, and experiment shows that such is the case above 32 deg. F., if its pressure is kept constant, the gas would double in volume with an increase in temperature above 32 deg. of 491.64 deg. F.

Since the volume of a gas at constant pressure varies as the absolute temperature [—460 deg. F. is absolute zero], if one pound of gas is at a temperature of 60 deg. F. and a second pound at 500 deg. F., the respective volumes at a given pressure would be in the ratio of 60 + 460 = 520 to 500 + 460 = 960.

The section on specific heat is particularly commendable. Mr. Pratt points out that in computations on combustion the mean specific heat and the specific heat at constant pressure should be used. He gives the values in Table III (Table 7 in his book) as the most authoritative at 60 and 600 deg. F.

TABLE III. MEAN SPECIFIC HEAT AT CONSTANT PRESSURE AND ORDINARY TEMPERATURES

Substance	Molecular Symbol	Mean Specific Heat 0–60 Deg. F.	0 600 Deg. F
Air	....	0.2381	0.2484
Oxygen	....	0.2160	0.2211
Hydrogen	....	3.3850	3.4750
Nitrogen	....	0.2349	0.2406
Carbon monoxide	....	0.2349	0.2406
Carbon dioxide	....	0.2008	0.2214
Water vapor	....	0.4542	0.4586
Methane	....	0.498	0.649
Ethylene	....	0.348	0.461
Sulphur dioxide	....	0.1544	.....

With the data of Table 8 in the book available, the development of formulas to give directly the theoretical amount of air necessary for the perfect combustion of any fuel is simple. Such formulas are given, beginning on page 49.

Mr. Pratt strikes a responsive chord in the reviewer when he says, on page 47: "It seems proper to emphasize here the necessity, where accurate results are desired, of considering flue-gas analyses *only* in conjunction with analyses of the fuel burned. As an example of the errors that may arise where the two analyses are not considered together, we may take the tables of preventable losses corresponding to varying percentages of carbon dioxide present in the flue gases, which are given in numerous publications.

Such tables give an arbitrary percentage of carbon dioxide, which, if it could be obtained, would represent no preventable loss, with increasing losses for lesser percentages of carbon dioxide. For any fuel there will be a definite percentage of carbon dioxide that must correspond to perfect combustion and therefore to zero preventable loss; but such percentage will vary not only for different classes of fuel, but even widely with different fuels of the same class. How wide this variation in carbon dioxide may be for perfect combustion with different fuels is indicated by the computations of combustion data given later [in the book], the range in examples of fuels taken being from 9.4 per cent. in the case of byproduct coke-oven gas to 25.1 per cent. for blast-furnace gas.

The book is 6 x 9 in., 114 pages. Frankly, it is not suited to the man who has not a fairly good "grounding" in the chemistry of combustion. Others would do well to gain a working knowledge of that subject before using the book.

In an early issue *Power* will publish some of the computations of combustion data which form the eleventh section of the book.

Oxyacetylene Welding and Cutting

The following rules for operation of oxyacetylene welding and cutting have been adopted by the Western Pennsylvania Division of the National Safety Council:

1. Under no condition should acetylene be used where the pressure is greater than 15 lb. per square inch.

2. Special care should be given to the storage of oxygen and acetylene tanks. Acetylene is classed as an explosive as other hydrocarbon gases and only a limited number of containers should be stored in one place. Oxygen tanks should be stored in a separate place from acetylene tanks.

3. Oxygen and acetylene tanks should not be allowed to remain near stoves, salamanders, furnaces, steam heaters or other sources of heat and should not be exposed unnecessarily to the direct rays of the sun, as an increase in the temperature of the gas will cause a corresponding increase in the pressure within the tank. Any excess of heat may also soften the fusible safety disk with which the tank is provided, causing it to blow out and permit the gas to escape.

4. Oxygen tanks should never be handled on the same platform with oil or grease which might find their way into valves on the tanks.

5. Oxygen and acetylene tanks should never be dropped or handled roughly and should never be stood on end unless fastened so as to prevent them from falling over.

6. Tanks should not be handled by crane, either magnetic or mechanical.

7. All empty tanks should be marked plainly with the word "empty" and returned promptly to the storeroom.

8. An open flame should never be used for the purpose of discovering leaks in acetylene tanks. Leaks can generally be detected by the odor of the acetylene gas, and their location can be determined by applying soapy water to the surface of the tank and watching for the soapy bubbles formed by the escaping gas.

9. No repairs to oxygen or acetylene tanks or equipment should be made or attempted. All defects should be reported promptly to the foreman, and by him to the manufacturer.

10. Leaking acetylene tanks should not be used, but should be placed in the open air and all open lights kept away from them. All leaking acetylene tanks should be reported promptly to the foreman and immediately returned to the manufacturer.

11. All open flames should be kept away from any place where there is any possibility of acetylene escaping.

12. Care should be taken to protect the discharge valves of the tanks from being bumped, as a jar may damage the valve and cause it to leak.

13. Grease in contact with oxygen under pressure may cause spontaneous ignition. Great care should be taken not to handle threads or valves with oily hands or gloves, and gages should not be tested with oil or any other hazardous carbon. If a lubricant must be used, the purest glycerin is permissible.

14. Gages, apparatus and torches requiring repairs should be sent to the manufacturer, and local repairs should not be attempted. Valve seats should never be replaced except by the manufacturer.

15. The use and operation of the pressure regulator or reducing valve on oxygen or acetylene tanks should be as follows: (a) Open the discharge valve on the tank slightly for a moment and then close it. This is to blow out of the valve any dust or dirt that might otherwise enter the regulator. (b) By means of the stud or nut connection on the regulator, connect the regulator to the discharge opening of the tank. (c) Release the pressure-adjusting screw of the regulator to its limit. (d) Open the needle valve slightly if there is one. (e) Open the discharge valve on the tank gradually to its full width. (f) Open the needle valve to its maximum if there is one. (g) Adjust the pressure regulating screw until the desired pressure is shown on the low-pressure gage.

16. The discharge valves on the tanks should be opened slowly and care should be taken to avoid straining or damaging them by the use of a hammer or improper wrench. A special wrench should be made for use in opening these valves in case they stick.

17. When the operation of the cutting or welding torch is stopped for a short time, the needle valve on the regulator should be closed, or the pressure-adjusting screw should be released to keep the pressure off the hose. The torches should be opened momentarily to let the pressure out of the hose lines.

18. All tanks should be inspected at the close of the day's work.

19. Proper precautions should be taken to protect the hose from flying sparks.

20. All hose should be examined periodically at least once every week. This should be done by cutting the hose off

at the end of the connection and examining it. In addition, after a few months' use, the hose should be cut off about two inches back of the connection and examined for defects. A defective hose should never be used.

21. Special care should be taken to avoid the interchange of oxygen and acetylene hose or piping, as this might result in a mixture of these gases that would be highly explosive. The practice of using right and left-hand threads is recommended.

22. White lead, grease or other similar substances should never be used for making tight joints. All joints and leaks in equipment should be made tight by soldering or brazing.

23. The oxygen and acetylene valves at the base of the torch should be tested daily for leaks.

24. Where hydrogen or other gas is used instead of acetylene, the same precautions should be observed as for acetylene.

25. A fire extinguisher should be carried as regular equipment to be used in case of fire.

26. Men using welding apparatus should wear suitable welding goggles for eye protection, having frames that are nonconductors of heat (not celluloid), side shields to protect against hot particles of metal, and lenses of proper color.

27. Operators' clothing should be fireproof.

28. If valves become frozen, they should be thawed by hot water, not by flame or hot metal rod.

29. Home-made generators should never be used as they are unsafe. As the Board of Underwriters has jurisdiction over all generators, only generators permitted by the underwriters should be used.

30. Where acetylene is used from generators or is piped through the plant, an approved water seal should be interposed between the generator and the piping system and individual water seals should be placed at each blowpipe. Water seals should be inspected daily, without fail.

31. Portable generators should not be used inside of the building.

32. Safety devices on tanks, generators or apparatus should not be removed or tampered with.

33. In welding brass or bronze, injurious fumes may be given off, making it desirable to wear a respirator.

34. Smoking while on duty should positively be prohibited.

35. Electric lights in a generator house should be inclosed in vapor-tight globes protected by the regulation guard.

36. Snap switches should be placed outside of the generator house in a suitable place, provided the house is isolated.

37. Piping which is used to carry acetylene or hydrogen should be painted a distinctive color so that it will not be possible to mistake that line for anything else.

38. The manufacturers should provide couplings for the hose which cannot be mistaken and put on the wrong hose. If the couplings could be made with proper connections, it would be impossible to make any mistake.

39. In storage houses where hydrogen or acetylene tanks are stored, the wiring should conform to the same rules as for the generator house so that it would be impossible to cause an explosion from defective wiring or a break in the bulb.

40. The valves on the piping should contain neither copper, brass nor bronze.

41. In opening the outlet valve of a full tank, do not remove the regulator.

42. The operator should not stand in front of the gages when opening the discharge valves on the tank. If the pressure goes off suddenly, it may possibly destroy the gage, and if it does, the glass and parts will be blown out at the front.

43. A label should be placed on every tank of oxygen that comes into any mill, that it should be kept away from grease. Some of the manufacturers put on a tag while others do not.

44. Acetylene is now capable of making a 24-in. cut. Beyond that it is necessary to use hydrogen.

New Society of Massachusetts Engineers

The initial meeting of the Engineering Society of Western Massachusetts was launched at a dinner of over 300 at the Hotel Kimball, Springfield, on the evening of Apr. 16. The speakers were Prof. L. P. Breckenridge, who discussed engineering organizations; W. S. Murray, who spoke on the conservation of natural resources with particular reference to a super-power system covering the territory between Boston and Washington; and Dr. George Otis Smith, director of the Geological Survey, who also spoke upon the power problem.

During the course of the evening there were received 1072 applications for membership. The following officers were elected: President, Charles L. Newcomb; vice presidents, C. C. Chesney and George E. Williamson; secretary and treasurer, W. E. Holmes. The following directors were also elected: Dr. H. C. Emerson, F. O. Wells, S. M. Greene, J. C. Robinson, E. E. Lochridge and G. P. B. Alderman.

The membership is divided into four classes: Honorary, full members, associate members and juniors. The initial fees and dues are each $5 for the three first classes and $3 for the fourth class. The third Tuesday in May has been fixed as the date for annual meetings.

New Publications

THE GREEN BOOK

Containing nearly 100 pages, the "Green Book, Progressive Combustion," just issued by the Green Engineering Co., of East Chicago, Ind., is an excellent example of modern publicity methods now favored by the progressive manufacturer. It is not the old-time catalog. Green products are thoroughly illustrated and the construction made evident, but the discussion is on an engineering basis. The book in fact is a treatise on combustion, including a survey of the coals of the world, their typical analyses and burning characteristics. The latter is such desirable information that in itself it should create a large demand for the new publication.

As an introduction the economic features of mechanical stokers, such as labor saving, fuel saving, increased capacity and smokelessness, are discussed. Coals are classified as to grade and firing characteristics, and attention is given to the four requirements that make a stoker automatic. The Green chain grates of the K and L types are fully illustrated and improvements such as rear drums in place of sprockets, chain skids in lieu of rolls, a perfected air-sealing system and water-cooled rear girder and ledge plates, emphasized. There is description of other Green products such as the "Sealflex" ventilated arch, the pressure waterback, the steam-jet ash conveyor and the cast-iron storage hopper.

A 17-page section devoted to combustion engineering gives the fundamentals of combustion, furnace design and draft, including chimney and breeching design, draft loss, combustion rates and boiler capacities. An instructive feature is the presentation of ten typical settings for different types of boilers equipped with chain grates to meet varying conditions.

In the concluding section coals of the world receive general comment and estimates are given of the coal reserves in North and South America, Africa, Asia, Europe and Oceania. Following are proximate analyses of these coals by name of seam or bed in the various states and countries in the United States and in the various foreign countries producing coal. Such information is most interesting and valuable to the engineer and should prove an excellent guide in the purchase of fuel or in the design of the boiler plant to burn a specific coal.

Obituary

George H. Phillips, president and treasurer of the Hewes & Phillips Iron Works, Newark, N. J., died at his home in Brielle, N. J., on the afternoon of Apr. 22. He had not been in the best of health for a year, but his illness took a serious turn only about a week before his death. Mr. Phillips was born in the old Phillips homestead on Lincoln Ave., Newark, over sixty-six years ago and lived in that city practically all his life, having removed to Brielle only five years ago. He received his early education at Newark Academy and the Hill School, Pottstown, Penn., after which he entered Cornell University. On his graduation from the university he became associated with the iron works in which his life has been spent. He was unmarried and is survived by three brothers and three sisters.

Marshall Ten Broeck Davidson, president of the M. T. Davidson Co., builders of the well-known line of "Davidson" pumps and pumping engines, died at his home in Brooklyn on Apr. 10. Mr. Davidson was one of the oldest members of the American Society of Mechanical Engineers, also a member of the Society of Naval Architects and Marine Engineers, the Naval Order of the United States, Associate Society U. S. Grant Post, No. 327, the Columbia County Association and life member of the Navy League. He was born in Albany, in 1837, and from his early boyhood showed great interest in steam machinery, particularly the locomotive and steamboat engines. In 1857 he entered a marine-engine machine shop, and later went to sea as assistant engineer. Upon the breaking out of the Civil War, he was assistant engineer on a steamer running from San Francisco to the various settlements on Puget Sound. He came east in 1862 as volunteer, second-assistant engineer in the naval service, but was requested to accept a position as chief engineer of an army transport, building at Wilmington, Del. At the close of the war, he became a contracting engineer, and in 1878 started the business which is now carried on in Brooklyn, N. Y., building pumps and pumping engines.

Personals

Alex Girtanner, formerly vice president of the American Steam Conveyor Corp., of Chicago, Ill., is now president of the Girtanner Engineering Corp. of New York, with offices at 1400 Broadway.

R. E. Thompson has been appointed manager of the Deming Ice and Electric Co., Deming, N. M., to succeed M. E. De France, who has gone to Trinidad, Colo., as superintendent of power for the Trinidad Electric Transmission Railway and Gas Co.

Engineering Affairs

The Canadian Association of Stationary Engineers will hold its annual convention and exhibition of power-plant equipment and supplies at Convention Hall, Brant Ave., Brantford, June 24, 25 and 26. An elaborate program has been provided, covering both the presentation of technical papers and special features.

Miscellaneous News

The Tallahassee Light and Power Co.'s plant was totally destroyed by fire Apr. 12, plunging the capital city of the state into semi-darkness, with the legislature in session and no adequate means of lighting the capitol, hotels or homes. The loss of the plant is estimated at $75,000.

Business Items

The Bailey Meter Co. will move its main office and works from Boston to Cleveland, Ohio, on May 1. The Boston office, with H. D. Fisher as manager, is retained to handle sales and engineering service work in the New England district. For the present New York and Philadelphia districts will be covered from Boston and all other districts will be covered from Cleveland.

Ball Bearing Manufacturers' Combine— Of interest to all users of bearings is the reorganization on May 1, whereby the products of the Hess-Bright Manufacturing Co., the S K F Ball Bearing Co., the Atlas Ball Co. and the Hubbard Machine Co. will be sold through one central organization. The new company, under the name of S K F Industries, Inc., will offer a comprehensive line of ball bearings, including the Hess-Bright deep-groove type, S K F self-aligning radial and thrust bearings, ball bearing pillow-blocks and shafting hangers.

The Curtis & Curtis Co., Bridgeport, Conn., has just completed an important addition to its plant. The new building is 150 x 125 ft. and includes an exhibition room and a new hardening and tempering department with all latest facilities.

Akerlow & Lundquist have opened an office at 415 Seventeenth St., Denver, and besides having the agency for boiler-room equipment, they will do general engineering work for power plants and coal and oil users.

The Chicago Pneumatic Tool Company has moved its Milwaukee office from Room 1305, Majestic Building, to Room 1418 in the same building, where more convenient quarters necessitated by the growing business of the company in this district have been obtained.

Trade Catalogs

Chas. A. Schieren Co., New York City, has issued Catalog No. 10 on "Schieren Leather Beltings," describing the different grades of belting, rawhide rope, cut lacing, lace leather, hydraulic leather, packing, belt cements, dressings, etc., with the general price list for each.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.80@3.35
Philadelphia, gross tons	4.20@4.90	5.00@5.40
New York, gross tons	4.50@5.25	5.35@5.80
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.65

Pocahontas and New River are quoted at $4.70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5.95	$7.80	Pea	4.80	6.55
Egg	5.85	7.70	Buckwheat	3.40	5.15
Stove	6.10	7.95	Rice	2.75	4.50
Chestnut	6.20	8.05	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.80 @ 3.10	2.95 @ 3.25
Clearfield County	2.65 @ 2.95	.....
Reynoldsville	2.65 @ 2.85	2.85 @ 2.95
Quemahoning	2.75 @ 2.95	2.95 @ 3.10
Somerset County (best grades)	2.75 @ 2.95	2.95 @ 3.10
Somerset County (poorer grades)	2.25 @ 2.50	2.50 @ 2.75
Western Maryland	2.25 @ 2.75	2.50 @ 2.75
Fairmont	2.10 @ 2.35	2.35 @ 2.50
Latrobe	2.10 @ 2.25	.....
Greensburg	2.35 @ 2.40	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.40 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.75	3.65
Stove	6.10	7.95	Boiler	2.50	3.50
Nut	6.20	8.05	Barley	2.25	3.15
Pea	4.80	6.40	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	.....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....
Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2.25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	.....	2.30	.....
2-in. lump	.....	.....	2.15

Williamson-Franklin rate to St. Louis is $1.07½; other rates 92½c.

New Construction

PROPOSED WORK

Mass., Campello—H. E. Keith & Co. will soon award the contract for the construction of a 64 x 71 ft. power house. Estimated cost, $56,000. Jenks & Ballou, 735 Grosvenor Bldg., Providence, R. I., Engr. Noted Jan. 21.

Mass., Lynn—J. Grossman, 401 Grossman Bldg., will install a steam heating plant in the 7-story apartment hotel which he plans to build on Lynn Shore Dr. and Wade St. Total estimated cost, $250,000.

Mass., New Bedford—H. T. Borden, Chn. of the Comn., 154 Fair St., will soon award the contract for the construction of a power house, laundry, etc., in connection with the hospital group, which it plans to build on Mt. Pleasant, Myrtle, Van Buren and Jefferson St. Total estimated cost, $100,000. J. R. Worcester & Co., 79 Milk St., Boston, Engr. Noted Feb. 11.

Conn., Bridgeport — The Carlisle-Cord-Tire Co., Andover, Mass., will install a steam heating plant and electric power in the 1-story, 150 x 250 ft. factory which it plans to build on Fairfield Ave. Total estimated cost, $100,000.

Conn., Bristol—E. Ingraham Co., 392 North Main St., has awarded the contract for the construction of a 5-story, 50 x 100 ft. factory to the H. Wales Lines Co., 134 State St., Meriden. A steam heating system and electric power will be installed in same. Total estimated cost, $100,000.

Conn., New London—The New Haven Dairy Co., Hazel St., New Haven, plans to build a 2-story artificial ice plant on Pequot Ave. Estimated cost, $50,000.

Conn., Wallingford—The Masonic Charity Foundation Co., Meriden, has awarded the contract for the construction of a 4-story, 86 x 105 ft. home to the H. Wales Lines Co., 134 State St., Meriden. A Brownell vapor heating system will be installed in same. Total estimated cost, $150,000.

N. Y., Antwerp—The Antwerp Light & Power Co. has had plans drawn for the development of the company's water power on the Indian River. Plans include the construction of a dam, flume and power house, transmission line and the installation of generator units. Address J. A. Baumert, Antwerp.

N. Y., Buffalo—The Armour Grain Co., Abbott Rd., is in the market for conveying and transmission equipment and grinders to be installed in the addition to its mill which it plans to build. Estimated cost, $25,000.

N. Y., Cambridge—The Rice Seed Co. will install a heating plant, temperature and humidity controlling equipment, etc., in the 75 x 275 ft. storehouse and shipping building which it plans to build near the Delaware and Hudson R.R. Estimated cost, $35,000.

N. Y., Long Island City—The Board of Education, 500 5th Ave., New York City, will install a steam heating plant in the 3-story, 100 x 100 ft. high school addition which it plans to build on Wilber Ave. Total estimated cost, $500,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., Long Island City—Loft, Inc., Broome and Center St., New York City, will install a steam heating plant in the 5-story, 150 x 200 ft. factory which it plans to build on Vernon Ave., Dayton to Hamilton St. Total estimated cost, $850,000. J. P. Dunn, 514 1st Ave., New York City, Arch.

N. Y., Madison—The War Department plans to install a new steam heating plant in the old stone quarters here. Estimated cost, $60,000.

N. Y., New York—Cuneo & Posta, 73 Washington Sq., will install a steam heating plant in the 5-story, 100 x 130 ft. garage which they plan to build at 541-551 West Broadway. Total estimated cost, $100,000. F. E. Vitolo, 56 West 45th St., Arch.

N. Y., New York—R. H. Macy & Co., Bway. and 34th St., has awarded the contract for the construction of a 17-story, 50 x 200 ft. addition to its department store at 149-155 West 34th St. to Marc Eidlitz, 30 East 42nd St. A steam heating plant will be installed in same. Total estimated cost, $500,000.

N. Y., New York—The National Association Building Corp., 25 West 45th St., will install a steam heating plant in the 20-story, arcade, store and office building which it plans to build at 27 West 43rd St., through to 26-28 West 44th St. Total estimated cost, $800,000. Starrett & Van Vleck, 8 West 40th St., Engr.

N. Y., New York—The New York Infirmary for Women & Children, 321 East 15th St., will install a steam heating plant in the 44 x 60 ft. dispensary which it plans to build at Livingston Place and 15th St. Total estimated cost, $155,000. Butler Rodman, 56 West 42nd St., Arch.

N. Y., New York—M. Rubin, 1969 Amsterdam Ave., will install a steam heating plant in the 2-story, 100 x 203 ft. garage which he plans to build at Jumel Pl. and 167th St. Total estimated cost, $200,000. F. Caplin, 16 Court St., Brooklyn, Arch.

N. Y., Salisbury Center—G. W. Boyle, Pur. Agt., Herkimer Co. (Herkimer), will install a steam heating system in the tuberculosis hospital which will be built on the Heller Farm here. Total estimated cost, $100,000.

N. J., Cape May—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a cold storage building at the Section Base here. Estimated cost, $50,000. Specification No. 3685. Noted Dec. 31.

N. J., Hopewell—W. C. Slack, 42 Fisher Pl., Trenton, plans to build a 1-story, 42 x 120 ft. refrigerating plant here. Estimated cost, $18,000.

N. J., Newark—Otto Heineman Co., Inc., 145 Jackson St., will install a steam heating plant in the 4-story, 80 x 400 ft. factory which it plans to build on Thomas St. Total estimated cost, $500,000. R. G. Cory, 39 Cortlandt St., New York City, Engr.

Penn., Pittsburgh—The Y. M. C. A. will install a heating system in the 4-story, 81 x 120 ft. association building which it plans to build on Center and Francis St. Total estimated cost, $100,000. E. B. Lee, Chamber of Commerce Bldg., Arch.

Md., Highlandtown (Baltimore P. O.)—Jones & Lamb Co., Pennsylvania and Fulton Ave., Baltimore, plans to remodel the plant of the Monumental Brewery Co., and construct several buildings on Lombard St., same to be used as meat packing plant and oil refinery. A steam heating system, engines and boilers will be installed in same. Total estimated cost, $500,000. C. C. Comstock, 110 West 40th St., New York City, Engrs.

Ohio, Cleveland—G. W. Hale, Leader-News Bldg., will install a steam heating system in the 3-story, 165 x 180 ft. garage which he plans to build on East 9th St. and Bolivar Rd. Total estimated cost, $250,000.

Ohio, Cleveland—The Purity Ice Cream Cone Co., 5119 Euclid Ave., will install a steam heating plant in the 4-story factory which it plans to build at 8804 Hough Ave. Total estimated cost, $100,000.

Ohio, Parma—The Board of Education will install a steam heating plant in the 3-story school which it plans to build. Total estimated cost, $100,000. Wright & Hohl, 407 American Trust Bldg., Cleveland, Arch.

Mich., Detroit—The Grand River Parish, Grand River and McGraw St., will install complete steam heating equipment in the 2-story 70 x 180 ft. school which it plans to build on Grand River and Quincy Ave. Total estimated cost, $130,000. Van Leyen, Schilling and Keough, 1121 Union Trust Bldg., Arch.

Mich., Detroit—The Seamless Steel Tube Co., 841 West Jefferson Ave., plans to build a power plant in connection with the factory which it plans to build on Wyoming and West Warren Ave. Total estimated cost, $1,700,000. A. A. Templeton, Pres.

Wis., Waupaca—F. H. Josslyn, Algoma Bldg., Oshkosh, plans to build a 2500 hp. hydroelectric power plant on the Little Wolf River. Estimated cost, $200,000. E. Orbison, Appleton, Engr.

Minn., Brainerd—The city will receive bids until May 8 for building a water system. Work involves (a) distribution system (1) furnishing pipe and castings, f.o.b. Brainerd, (2) fire hydrants, (3) valves and boxes, (4) laying pipe; (b) buildings including pumping station, pump houses, pump pits and manholes for 2 tubular well groups, also 800,000 gal. reservoir; (c) pumping plant including the removal of two 6-in. motor driven centrifugal pumps to the new pumping station and installing 2 motors and engine driven centrifugal pumps for well system together with necessary pipe and fittings. L. P. Wolff, Guardian Life Bldg., St. Paul, Consult. Engr.

Minn., Virginia—The Commissioners of St. Louis Co. (Duluth) will install a steam heating and mechanical ventilating system in the 3-story addition to the court house which they plan to build. Total estimated cost, $150,000. W. H. Bargen, Co. Aud.

Neb., Omaha—The Skinner Packing Co., 904 First National Bank Bldg., will receive bids until May 15th for the construction of an 8-story, 99 x 132 ft. cold storage plant on 12th and Douglas St. Estimated cost, $500,000. H. C. Christianson, 7258 Union Ave., Chicago, Ill., Engrs. Noted Apr. 1.

Mo., St. Louis—The St. Louis Wholesale Cut Flower Co., 1419 Pine St., will install a refrigerating system in the 50 x 109 ft. flower storage building which it plans to build at 1406-8 Pine St. Estimated cost, $50,000. Grewe Construction Co., Century Bldg., Engr.

Mo., St. Louis—Swift & Co., 39th and Papin St., will soon award the contract for the construction of a 1-story, 60 x 60 ft. addition to its boiler house. Estimated cost, $70,000. K. A. Green, Supt.

Ore., Warrenton—The Mountain Meat Co., Portland, is having plans prepared for the construction of a cold storage plant here. Address W. C. Pratt, c/o company.

Cal., Sacramento—The city plans election in May to vote on $2,400,000 bonds to purchase a site and build a pumping plant, filtration plant and caisson in the Sacramento River. F. C. Miller, City Hall, Engr.

Que., Montmagny—The city plans to build a power house, dam, electric line and install machinery. Estimated cost, $400,000.

P. I., Cavite—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install power plant equipment here. Estimated cost, $90,000. Specification No. 3871.

CONTRACTS AWARDED

N. Y., Ogdensburg—The Board of Education has awarded the contract for installing a heating and ventilating system in P. S. No. 2 to the American Warming & Ventilating Co., 317 Pennsylvania Ave., Elmira. Estimated cost, $7427.

N. Y., Rockaway—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for the construction of a pump house for electric remote control gasoline system at the Naval Air Station here from C. Mead, 38 Park Row, New York City, $1664; Rangley Construction Co., 405 Lexington Ave., New York City, $1739 (45 days); Post & McCord, 101 Park Ave., New York City, $1923 (60 days). Specification No. 3836.

N. Y., Thiells—L. F. Pilcher, State Architect, has awarded the contract for building an addition to the central heating plant at Letchworth Village, to the G. B. Wright Co., Garnersville, $32,200; contract for electric work has been awarded to the W. H. Straut Co., 14 New Main St., Haverstraw, $850.

Penn., Philadelphia—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing pumping equipment in Navy Yard here to the W. G. Cornell Co., Colonial Trust Bldg. Estimated cost, $7286 (45 days).

Wis., Menasha—The Gilbert Paper Co. has awarded the contract for the construction of a 60 x 167 ft. power house to C. R. Meyer Sons, 50 State St., Oshkosh. Estimated cost, $75,000.

Ore., Salem—The Pheasant Northwest Products Co., Ferry St., plans to build a boiler house adjoining the company's plant between Trade and Ferry St. Estimated cost, $5000. Work will be done by day labor.

Cal., Glendale—The city has awarded the contract for furnishing electrical materials as follows: U. S. Steel Products Co., Rialto Bldg., San Francisco, 13,600 lbs. 2.-0 triple braid copper wire at $19.42 per 100 lbs. f.o.b. Los Angeles; General Electric Co., Rialto Bldg., San Francisco, 60 kv.-a., 150 ampere type C induction feeder at $2238, f.o.b. Los Angeles; Pacific Electric Manufactdring Co., 827 Folsom St., San Francisco, 3-pole, single-throw, 15,000-volt, 200-ampere, oil circuit breaker at $725, f.o.b. Los Angeles.

Cal., Pasadena—The City Light Department has awarded the contract for furnishing electrical material as follows: the Ananconda Copper Co., 42 Bway., New York City, copper wire; Maloney Electric Co., San Fernando Bldg., Los Angeles, 2 transformers.

The Modern Aladdin—

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